



Maritime Technology and Research

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Research Article

Periscoping performance of classification societies in maritime safety from the prism of the Abuja MoU on port states control

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Article information

Received: August 27, 2022

1st Revision: October 30, 2022

2nd Revision: December 8, 2022

Accepted: December 13, 2022

Keywords

Classification society,
Maritime safety,
Performance,
Port state,
Control

Abstract

The study investigated the performance of individual classification societies in the Abuja Memorandum of Understanding (MoU) on Port States Control (PSC) with a view to providing empirical evidence and information on the levels and rates of change of inspected ships, detained ships, and deficient ships recorded by PSC Officers for ships certified and classed by individual classification societies. The study estimated the average deficiency to inspection ratio (ADIR) and mean detention to inspection ratio (MDIR) for ships certified and classed by identified individual classification societies in the Abuja MoU regime. Secondary data covering the period between 2015 and 2020 sourced from the database of the Abuja MoU administration was used. The findings indicated that Germanischer Lloyds, CCS-China, KRS-Korea, NNK-Japan, RMRS-Russia, Lloyds Register, London, Bureau Veritas, Det Norsk Veritas, ABS-USA, and RINA-Italy have better performance with regards to maritime safety in the Abuja MoU regime, as shown by the MDIR scores. Thus, they dominated ship-owners' preference for ship classification in West and Central African waters between 2015 and 2020. The trend of ship detention following compromised seaworthiness in the jurisdiction of the Abuja MoU on PSC for vessels certified by the International Naval Survey Bureau (INSB), CCS-China, Germanischer Lloyds (GL), International Register of Ships, Lloyds Register of Ships (LR), and NKK-Japan have negative coefficients of average rate of change, which indicates a decreasing trend in the number of vessels detained between 2015 and 2020; the rest of the classification societies, with positive coefficients of average rate of change, show an increasing trend in the number of ships detained for deficiencies that compromised seaworthiness; classified and registered by each classification society. Vessels classified by GL with ADIR of 0.034 (3.4 %) showed the least likelihood of having safety defaults and deficiency. It is recommended that the performance of poorly performing classification societies in upholding maritime safety standards should be improved. This implies that classification societies with average deficiency to inspection ratios (ADIR) of higher than 0.10 (10 %) should be reduced, while classification societies with mean detention to inspection ratios (MDIR) of 0.01 (1 %) and higher should be reduced.

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1. Introduction

Ship classification societies are organizations which:

(i) publish their own vessel classification rules covering technical requirements in relation to the design, construction, and survey of ships, and have the capacity to (a) apply, (b) maintain, and (c) update those rules and regulations with their own resources on a regular basis;

(ii) verify compliance with these rules during construction and periodically during a classed ship's service life;

(iii) publish a register of classed ships;

(iv) are not controlled by, and do not have interests in, ship-owners, shipbuilders, or others engaged commercially in the manufacture, equipping, repair, or operation of ships; and are authorized by a flag administration, as defined in Safety of Life at Sea (SOLAS) Chapter XI-1, Regulation 1, and listed accordingly in the International Maritime Organization's (IMO) database, Global Integrated Shipping Information System (IACS, 2017).

The key objective of classification societies and ship classification programs is the enhancement of maritime safety through the establishment and implementation of high technical standards of ship design, manufacture of parts, construction, operation, and maintenance (Lai et al., 2021). Classification societies in the implementation of the above objective(s) deploy their expertise in setting standards for safe construction, operation, and maintenance of vessels and, thus, provide certification to ships satisfying the standards of classification. Thus, shipyards and individual ship-owners engage the services of classification societies to ensure that the ships in their fleet are designed, built, operated, and maintained in compliance with safety rules and standards of classification societies of their choice; while the classification society issues class certificates for such ships that have complied to its standard rules of design, construction, operation, and maintenance. According to the IACS (2017) and Bevan (2014), class certificates issued by individual classification societies to ship-owners are not a guarantee of the seaworthiness of a ship, implying that, notwithstanding the objectives and functions of classification societies to enhance maritime safety through the development and implementation of design, construction, operation, and maintenance standards, the issue of seaworthiness of a ship is a factor which must be assured by the ship-owner at any point in time, since the classification society may not be directly involved or present at all periods of the operation of the vessel once engaged in trade.

However, in as much as classification societies form part of the group of important stakeholders in the development and setting of safety standards in the shipping industry, ascertaining the structural strength and integrity of a ship's hull and its fittings, determining the reliability and function of the propulsion steering systems, power generation, and other systems on the ship, and carrying out periodic surveys to ensure that vessels comply with minimum safety rules, regulations, and standards, they are critical stakeholders in the implementation of maritime safety and their roles in implementation and improving maritime safety cannot be wished away. The actions and inactions of ship classification societies can make or mar the outcome of maritime safety administration in global waters. Thus, even when the duty of the assurance of the seaworthiness of a vessel rests with the ship-owners, the ship-owner's judgment and decision regarding the above are influenced by the decisions of the classification society as to whether such vessels complied satisfactorily with the standard rules of the classification society and other IMO requirements (Oritse, 2019; Ozcavir, 2008; Zeitler, 2014; Bell, 1993; Nwokedi et al., 2019). This is partly the reason that ship-owners engage the services of classification societies- to ensure that judgments about the seaworthiness and safety of their vessels are rightly correct, since classification societies are the developers and custodians of maritime safety standard rules and regulations (Lai et al., 2022). Thus, vessels certified by more reputable classification societies find it easier to be engaged into trade (chartered), since they are believed to be safer/more seaworthy than others certified by some less reputable classification societies and which experience more difficulty in getting engaged into trade (charter contracts).

Following from the above background, we define the performance of individual classification societies in the context of this study as the ability of a classification society to satisfactorily deliver on the objectives of ship classification for which it is contracted by the ship-owner. This can be appraised from the perspective of the number of vessels classified by it that are compliant with standard IMO safety regulations and rules (Yan & Wang, 2019; Molenaar, 2010). It is a measure of the outcome of ship classification achieved by the classification society over a given period of time. Such an outcome may be measured in terms of the number of vessels it has surveyed/inspected and certified over time, the number of vessel in the class/register of the classification society that have no defects and have shown total compliance with safety standards over time, the number of vessels certified by the classification society whose seaworthiness is marred (deficient and detainable vessels), etc. As earlier identified, the performance and effort of a given classification society affects the safety standards and ratings of ships in its register, the shippers' perception of the seaworthiness of the vessels certified by it, and the overall performance of the classification society with regards to implementation of maritime safety standards (Hozairi et al., 2019; Jones, 2013). This, equally, has implications on the choice and preference of classification society by ship-owners, which may affect the fortunes of the classification society.

Although the available empirical literature provides no definitive basis for assessment, investigation of the performance of major classification societies in the implementation of maritime safety in the shipping industry shows the United Nations Convention on the Law of the Sea (UNCLOS) is an umbrella convention concerned with many aspects of the sea and its uses, including the granting of registration of a ship by a flag state (Cariou et al., 2009). According to Yang and Yin (2018) and Osman et al. (2020), UNCLOS empowers the flag state to exercise a certain level of authority over ships in its register to ensure compliance with standard safety rules and seaworthiness. Under Article 94 of UNCLOS, flag states are mandated to exercise effective control over ships in its register to implement measures that are necessary to ensure safety at sea and vessel seaworthiness. Similar to flag state regulations and measures to enhance maritime safety, the IMO also developed the Port States Control (PSC) instrument in 1978, by which it empowered port states to form regional alliances and fashion out memoranda of understanding (MoUs) as a measure to enhance ship safety in the course of navigation (Alderton & Winches, 2018; Abuja MoU, 2015). The approach of implementation of PSC is for port states to inspect foreign vessels in their ports in order to ensure ship-owners' compliance with IMO maritime safety standards, rules, and regulations. It is obvious from the foregoing that safety inspections and surveys carried out by the flag states at the point of ship registration in line with the provisions of UNCLOS, and ship surveys implemented by the port states in implementation of the provisions of Port States Control (PSC) MoUs could reveal both classification society and ship-owners' performances with regards to their individual duties of implementing standard maritime safety rules and regulations. This is because both obligations (classification society safety survey and ship owner's obligations) are deemed fulfilled prior to flag state and port state inspections. Similarly, the implementation of Port States Control could form a basis for the investigation of the efforts of flag states in the implementation of maritime safety standards. In line with the aforementioned, we conceptualized the summary of the levels and of individual organizations with responsibility for developing and implementing maritime safety standards, as shown in **Figure 1** below.

Thus, the respective performances of the classification society in ship safety, the ship-owners in implementing safety standards, and the implementation of the IMO safety regulations can be assessed through the efforts of the flag states and the port states in the implementation of the provisions of UNCLOS and Port States Control (PSC) MoUs, respectively.

In the West and Central African sub-regions covered under the Abuja MoU on PSC, available empirical studies that provide information on the performance of ships classified by individual classification societies operating in the waters of the region, with regards to compliance

with maritime safety standards, are lacking. This has led to uninformed choice and preference of classification societies to transact with by ship-owners from the region.

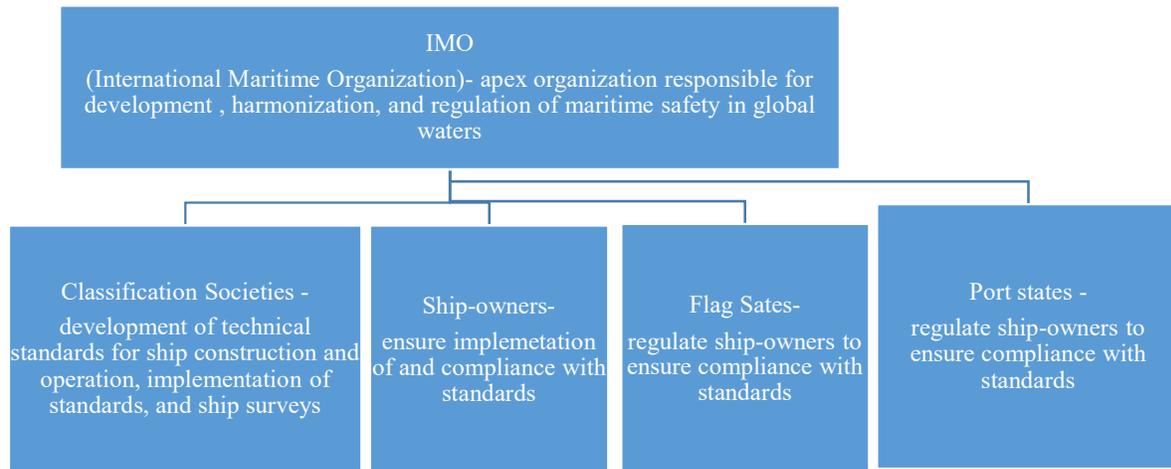


Figure 1 Levels of development and implementation of maritime safety regulations and standards and the responsible organizations involved.

Source: prepared by authors.

The goal of this study, therefore, is to examine the performances and efforts of identified individual classification societies in maritime safety in the jurisdiction of the Abuja MoU on PSC. The Abuja MoU on PSC encompasses the PSC administration agreement of 16 maritime nations in the West and Central African sub-region. The MoU provides regional cooperation between the PSCs of the member countries and reduces the burden and need for a given country to solely inspect all ships calling to her ports (Paris MoU, 2016; Abuja MoU, 2019). The membership currently comprises Benin, Cape Verde, Congo, Cote D' Ivoire, Gabon, The Gambia, Ghana, Guinea, Liberia, Mauritania, Namibia, Nigeria, Sierra Leone, Senegal, South Africa, and Togo. The core objectives of PSC regimes include:

(i) To identify ships which do not comply with internationally accepted safety standards set out in IMO conventions.

(ii) To impose controls to ensure that non-compliant ships trading within the jurisdictions of the coastal states are brought into compliance with the safety standards and provisions of the IMO conventions guiding the safety of ship and shipping operations.

(iii) To determine the compliance levels of ships with international conventions and codes governing maritime safety, marine pollution, and the living and working conditions of seafarers on board ships, and;

(iv) To complement the efforts of classification societies and, particularly, flag states in compelling compliance of ships and encouraging effective implementation by flag states (Abuja MoU, 2020).

Having established the roles and importance of classification societies in the development, implementation, and promotion of maritime safety in the global shipping industry, the aforementioned objectives of Port States Control regimes imply that the performances, outcomes, and efforts of individual classification societies in enhancing maritime safety can be assessed and understood from the outcomes of ship inspections/surveys implemented by PSC regimes, such as the Abuja MoU on PSC (Tilmaz, 2020; Cairou et al., 2006). Since each vessel inspected for deficiencies within the jurisdiction of the Abuja MoU on PSC belonged to or is certified by a given classification society which originally certified such ships as having met the safety rules,

regulations, and standards of the classification, ship inspection data from the Abuja PSC MoU regimes, and other PSC MoU regimes which provide details and outcomes of ship inspection such as:

- (i) Detainable deficiency,
- (ii) Deficiency that needs to be corrected before a given ship departs the port of inspection,
- (iii) Deficiency that needs to be corrected within a specified time range, and;
- (iv) Non deficient ships,

should provide an understanding of the performance and effort of individual classification societies for ships certified by them. Inspection data from the Abuja MoU on PSC can, thus, provide understanding of the performance and efforts of individual classification societies for ships trading in the West and Central African region (Yuan et al., 2020; Akyurek & Bolat, 2021). The specific objectives of the study are, thus, to provide the trends and rates of change coefficients of the number of ships classified by individual classification societies trading in West and Central African waters, trends and rates of change coefficients of vessels certified by individual classification societies with detainable deficiencies, and trends and rates of change coefficients of vessels certified by individual classification societies having deficiencies in safety standards, rules, and regulations within the jurisdictions of the Abuja MoU on PSC regime. These will provide evidence for the ranking of the performance and efforts of the major classification societies, in line with the outcomes of ship inspection data from the Abuja MoU on PSC regime. The historical performance of the individual classification societies in the jurisdiction will also provide a basis for ship-owners' choice and preference of classification societies for their vessels. The projection of future performance targets and determination of performance benchmarks by individual classification societies will also be achieved using the results of the study. The average deficiency to inspection ratio (ADIR) and the mean detention to inspection ratio (MDIR) of ships operating in the jurisdiction of the Abuja MoU on PSC classifying the individual classification societies are also determined. The study also offers a basis for the appraisal and comparison of the level of contribution of individual classification societies to ship-owners' compliance with maritime safety regulations and standards within the jurisdiction of the Abuja MoU on Port States Control.

2. Data and methods

The study used an ex post-facto research design. It also used time series secondary data on the number of vessels classified by individual classification societies trading within the West and Central African maritime region. The data was obtained from the yearly inspection report of the Abuja MoU on Port States Control. The data covers the statistics of the number of ships certified by each identified classification society inspected in the Abuja MOU regime per annual (ISP), the number of deficient ships (DFS) classified by individual classification society in the Abuja MoU on PSC, and the number of ships with detainable deficiencies (DET) classified by individual classification societies in the Abuja MoU jurisdiction. The data obtained covered a period of six (6) years from 2015 to 2020.

The study employed the average rate of change method to estimate the average rates of change coefficients of the number of ships certified by each identified classification society in the Abuja MoU regime between 2015 and 2020. Similarly, the average rate of change coefficients of deficient ships in the Abuja MoU regime certified by individual classification societies and detainable vessels in the Abuja MOU on PSC regime certified by individual classification societies were also determined by the use of average rate of change analysis. Recall that, for the number of ships certified by individual classification societies inspected in the Abuja MoU on PSC, deficient vessels and vessels with detainable deficiencies certified by individual identified classification societies indicate the performance of the respective classification societies with regards to the outcomes of port states control in the section in the Abuja MoU regime.

The ship inspection efforts/performance of the Abuja MoU on PSC regime is a function of time; that is:

$$ISP = F(t) \tag{1}$$

Therefore, for a given classification society, e.g., the American Bureau of Shipping (ABS), the number of ships certified by ABS inspected in the Abuja MoU regime is dependent on time (t); we write that:

$$ISP_{abs} = F(t) \tag{2}$$

For Bureau Veritas (BV) classification society,

$$ISP_{BV} = F(t) \tag{3}$$

For China Classification Society (CCS),

$$ISP_{CCS} = F(t) \tag{4}$$

The study identified about 21 classification societies used in the study, and the inspection performance of ships certified by each classification society is dependent on time, as shown generally in Eq. (1).

The average rate of change of inspections carried out by port state inspection officers on vessels certified by each of the identified 21 classification societies can be estimated relative to the time changes ∂t over which the changes occurred.

Average rate of change coefficient of inspection frequency of ships certified by individual classification societies = $\frac{\partial ISP_t}{\partial t}$, (5)

For the American Bureau of Shipping (ABS), the average rate of change coefficient for the number of vessels certified by the ABS inspected in the Abuja MoU regime over the period is:

$$\frac{\partial ISP_{ABS}}{\partial t} \tag{6}$$

where t = time interval covered in the study = 10 years period. The average rate of change coefficient of inspection effort will provide evidence for the direction of the performance of the Abuja MoU with regards to the number of inspections over the period; that is, whether the inspection effort is increasing or declining, and by what average rate. Similarly the average rate of change coefficient of inspection effort for each the individual classification societies identified in the study was determined.

A trend line determined by employing ordinary least square (OLS) regression, where time is the explanatory variable, estimates the average rate of change coefficients of frequency of inspection of vessels certified by each classification society in the Abuja MoU on PSC regime over the period as the coefficient of regression (β) in each case, such that:

$$ISP_t = a + \beta t + \varepsilon \tag{7}$$

Using Eq. (7), this study estimated the rates of change of inspection frequency of ships certified by each of the individual classification societies used in the study in the Abuja MoU on PSC between 2015 and 2020.

Similarly, the number of deficient ships DFS_t certified by individual classification societies and detainable inspections/ships DET_t certified by individual classification societies in the Abuja MoU jurisdiction are functions of time; that is:

$$DFS_t = F(t) \tag{8}$$

and

$$DET_t = F(t) \tag{9}$$

Based on Eqs. (8) and (9), the study determined the average rate of change coefficients of deficient ships (DFS) certified by individual classification societies identified in the study as:

$$\frac{\partial DFS_t}{\partial t} \tag{10}$$

Similarly, the average rate of change coefficients of detainable ships certified by individual classification societies in the Abuja MoU jurisdiction is:

$$\frac{\partial DET_t}{\partial t} \tag{11}$$

Trend analysis is also used to estimate the average rate of change coefficients of deficient ships and detainable ships (unseaworthy) ships certified by individual classification societies in the Abuja MoU on PSC as the coefficients of regression.

It is important to also note that both detainable inspections/ships and deficient ships certified by individual classification societies in the Abuja MoU on PSC regime are functions of the number or frequency of inspections carried out of ships certified by the given classification society.

Thus, the total number of ships certified by a given classification society over time t is given as:

$$ISP_t = \sum DFS_t + DET_t + NDDSS_t \tag{12}$$

where: $NDDSS_t$ = non deficient, non-detainable safe ships certified by the classification society identified over the given time period t.

DET_t = detainable unseaworthy ships certified by the classification society identified by inspectors over the time period t.

DFS = deficient ships identified by inspectors certified by the individual classification society over the time period t.

$$NDDSS_t = ISP_t - DET_t - DFS_t \tag{13}$$

$$DET_t = ISP_t - NDDSS_t - DFS_t \tag{14}$$

$$DFS_t = ISP_t - NDDSS_t - DET_t \tag{15}$$

Using Eq. (13) the study determined the number of non-deficient, non-detainable safe ships that satisfied all IMO safety regulations certified by individual classification societies in the Abuja MoU on PSC jurisdiction. We also employed the simple percentage method to determine the percentages of safe and seaworthy vessels certified by the individual classification societies trading in the jurisdiction of the Abuja MoU on PSC as a percentage of the total number of ships certified by those classification societies within the Abuja MoU jurisdiction. The same method was applied to determine the percentage of deficient and detainable ships certified by individual classification societies in the Abuja MoU regime.

The study also employed ratio analysis to estimate the average deficiency to inspection ratio (ADIR) and mean detention to inspection ratio (MDIR) of vessels classed and certified by individual classification societies in the Abuja MoU on PSC jurisdiction between 2015 and 2020. The analyses were implemented with the use of the MATLAB and SPSS software.

3. Results and discussion of findings

Table 1 shows the result of the study on the trends, quantum, and average rate of change coefficient of ships certified by individual classification societies inspected within the jurisdiction of the Abuja MoU on PSC. The results show that the respective mean number of vessels inspected in the jurisdiction of the Abuja MoU on PSC per annum, certified by the American Bureau of Shipping (ABS), Bureau Veritas (BV), China Classification Society (CCS), Croatia Register of Ships (CRS), Det Norsk Veritas (DNV), and Indian Register of Shipping and International Naval Survey Bureau (INSB) is 301.500, 413.00, 101.8333, 2.333, 86.1667, 6.3333, and 14.6667, respectively, with respective standard deviations of 54.81879, 85.13754, 19.36406, 1.86190, 70.35174, 3.72380, and 4.8853, respectively. Similarly, the mean number of vessels certified by the International Register of Ships, Germanischer Lloyds (GL), Korea Classification Society (KCS), Korea Register of Ships (KRS), Lloyds Register of Ships (LR), Polski Register Statkow (PRS), and Panama Maritime Documentation Service (PMDS) inspected in the jurisdiction of the Abuja MoU on PSC between 2015 and 2020 is 3.1667, 118.500, 1.0000, 54.500, 387.6667, 5.8333, and 1.000, respectively, with respective standard deviations of 2.04124, 118.35328, 0.63246, 19.48076, 167.00499, 2.63944, and 0.63246, respectively. The Panama Register Corporation (PRC), Recistro Italiano Navae (RINA), Russian Maritime Register of Shipping (RMRS), Nippon Kaiji Kyokai (NKK), Vietnamese Register of Shipping (VRS), Turkish Lloyds (TL), and Others (other classification societies not individually identified in **Table 1**) have respective mean scores of 1.333, 116.83, 38.00, 497.83, 3.00, 3.67, and 9.33 vessels each inspected within the Abuja MoU on PSC between 2015 and 2020, with standard deviations of 1.21, 40.54, 8.81, 103.768, 2.366, 2.066, and 7.005, respectively. The implication is that vessels certified and classed by Nippon Kaiji Kyokai (NKK), with a mean inspection score of 497.83 per annum, dominate vessels trading in and inspected by the Abuja MoU on PSC between 2015 and 2020. Thus, ship-owners in the jurisdiction of the Abuja MoU on PSC show the highest preference for Nippon Kaiji Kyokai (NKK) than any other classification society. This is followed by vessels certified by Bureau Veritas, with a mean inspection score of 413.0000, Lloyds Register of Ships (LR), with a mean inspection score of 387.67, American Bureau of Shipping (ABS), with a mean inspection score of 301.5000, and Germanischer Lloyds, with a 118.5000 mean inspection score. The preference of classification society by ship-owners, which is indicated by the mean number of vessels certified by each individual classification society inspected within the jurisdiction of the PSC MoU, has implications on the performance of vessels classed by each society with regards to maritime safety standards, rules, and regulations. This corroborates the findings of Yaun et al. (2020), who found that ships classified by Nippon Kaiji Kyokai (NKK) recorded the highest inspection frequency in the Paris MoU. The safety performance of each of the identified classification societies, vis a-vis the number of inspections carried, the number of deficiencies identified, and detentions will be discussed further under the detention to inspection ratio and deficiency to inspection ratio in subsequent

sections of this study. **Figure 2**, below, shows the ranking of the classification societies in decreasing order of mean number of vessels certified and classed by each, inspected within the jurisdiction of the Abuja MoU on PSC between 2015 and 2020.

Table 1 Ship Inspection (ISP) Scores/frequency of vessels certified by individual classification societies in the Abuja MoU on PSC Jurisdiction between 2015 and 2020.

| Classification society | Mean number of ships inspected (ISP _t) | Standard deviation | Regression constant | Rate of change Coefficient = $\frac{\partial ISP_t}{\partial t}$ |
|---|--|--------------------|---------------------|--|
| American Bureau of Shipping (ABS) | 301.5000 | 54.81879 | 280.800 | 5.914 |
| Bureau Veritas (BV) | 413.0000 | 85.13754 | 353.400 | 17.029 |
| China Classification Society (CCS) | 101.8333 | 19.36406 | 97.333 | 1.286 |
| Croatia Register of Ship (CRS) | 2.3333 | 1.86190 | 0.933 | 0.400 |
| Det Norsk Veritas (DNV) | 86.1667 | 70.35174 | 208.867 | -35.057 |
| Indian Register of Shipping (IRS) | 6.3333 | 3.72380 | 0.733 | 1.600 |
| International Naval Survey Bureau (INSB) | 14.6667 | 4.88535 | 16.467 | -0.514 |
| International Register of Ships (IRS) | 3.1667 | 2.04124 | 0.067 | 0.886 |
| Germanischer Lloyds (GL) | 118.5000 | 118.35328 | 322.200 | -58.200 |
| Korea Classification Society (KCS) | 1.0000 | 0.63246 | 0.800 | 0.057 |
| Korea Register of Ships (KRS) | 54.5000 | 19.48076 | 31.400 | 6.600 |
| Lloyds Register of Ships (LR) | 387.6667 | 167.00499 | 289.267 | 28.144 |
| Polski Register Statkow (PRS) | 5.8333 | 2.63944 | 1.533 | 1.229 |
| Panama Maritime Documentation Services (PMDS) | 1.0000 | 0.63246 | 0.600 | 0.114 |
| Panama Register Corporation (PRC) | 1.3333 | 1.21106 | -0.067 | 0.400 |
| Recistro Italiano Navae (RINA) | 116.8333 | 40.54339 | 92.733 | 6.886 |
| Russian Maritime Register of Shipping (RMRS) | 38.0000 | 8.80909 | 30.800 | 2.057 |
| Nippon Kaiji Kyokai (NKK) | 497.8333 | 103.76785 | 389.333 | 31.000 |
| Vietnamese Register of Shipping (VRS) | 3.0000 | 2.36643 | 3.000 | 0.000 |
| Turkish Lloyds (TL) | 3.6667 | 2.06559 | 2.467 | 0.343 |
| Others | 9.3333 | 7.00476 | 13.133 | -1.086 |

Source: authors' calculation.

The coefficient of average rate of change of ships certified by the individual classification societies inspected in the jurisdiction of the Abuja MoU on PSC over the period covered in the study shows an average rate of change coefficients of ships inspected in the Abuja PSC regime certified by the America Bureau of Shipping (ABS), Bureau Veritas (BV), China Classification Society (CCS), Croatia Register of Ships (CRS), Det Norsk Veritas (DNV), Indian Register of Shipping, and International Naval Survey Bureau (INSB) of 5.914, 17.029, 1.286, 0.400, -35.057, 1.600, and -0.514, respectively. Thus, while the inspection of vessels certified and classed in ABS, BV, CCS, CRS, and Indian Register of Shipping increased annually over the period, the inspection of vessels certified and classed by DNV and INSB in the Abuja PSC regime decreased annually between 2015 and 2020. Similarly, the average rate of change coefficient of ships inspected in the Abuja PSC regime, classed and certified by the International Register of Ships, Germanischer Lloyds (GL), Korea Classification Society (KCS), Korea Register of Ships (KRS), Lloyds Register of Ships (LR), Polski Register Statkow (PRS), and Panama Maritime Documentation Service (PMDS) was 0.886, -58.200, 0.057, 6.600, 28.144, 1.229, and 0.114, respectively. Germanischer Lloyds (GL), with a negative coefficient of average rate, shows a decreasing trend in the number of

ships certified by it that were inspected in the Abuja MoU jurisdiction. Others with positive coefficients of average rate of change indicate an increasing trend over the period. Moreover, the Panama Register Corporation (PRC), Registro Italiano Navae (RINA), Russian Maritime Register of Shipping (RMRS), Nippon Kaiji Kyokai (NKK), Vietnamese Register of Shipping (VRS), Turkish Lloyds (TL), and others (other classification societies not individually identified in **Table 1**) have respective average rates of change coefficients of 0.400, 6.886, 2.057, 31.000, 0.000, 0.343, and -1.086. The implication is that, while the demand for the services of some classification societies by ship-owners in the jurisdiction of the Abuja MoU on PSC is increasing over the period, that of some others is decreasing. For example, INSB, DNV, and GL have negative coefficients of average rate of change, indicating a declining trend in the demand for their services by ship-owners operating in the jurisdiction of the Abuja MoU on PSC between 2015 and 2020, while other classification societies with positive rate of change coefficients experienced increased service demand over the same period. This also may have implications on ship-owners' perception of the level of safety performance of vessels classified and certified by each identified individual classification society. The regression constant when related to the rate of change coefficient provides the trend equation that offers a basis for the projection of the number of ships certified by each identified individual classification society inspected in the Abuja MoU on PSC. For example, the trend of the frequency of ships certified by the American Bureau of Shipping (ABS) inspected in Abuja MoU jurisdiction between 2015 and 2020 is:

$$ISP_{ABS} = 280.800 + 5.914t \tag{16}$$

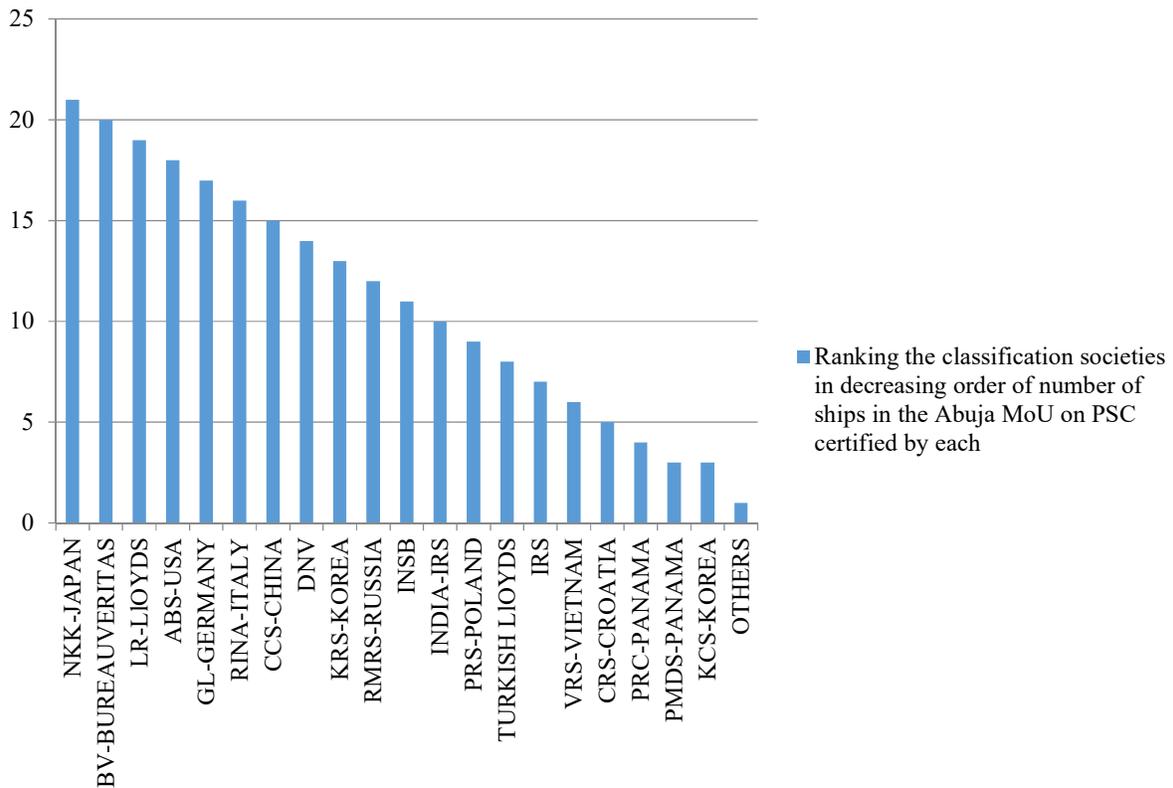


Figure 2 Ranking the classification societies in decreasing order of ship-owners' preference and number of ships certified by each in the Abuja MoU on PSC classified by each.
 Source: prepared by authors.

In a similar manner, the trends of inspection of ships certified by the various classification societies in the Abuja MoU regime can be determined. To assess the level of deficient vessels classed and certified by individual classification societies inspected in the Abuja MoU regime, see **Table 2** below.

Table 2 Mean Scores of ships with deficiency in safety standards, rules, and regulations certified by individual classification societies in the Abuja MoU on PSC jurisdiction between 2015 and 2020.

| Classification society | Mean scores of deficient vessels (DFS_t) | Standard deviation | Regression constant | Rate of change Coefficient of = $\frac{\partial DFS_t}{\partial t}$ |
|---|--|--------------------|---------------------|---|
| American Bureau of Shipping (ABS) | 25.5000 | 4.8887 | 21.600 | 1.114 |
| Bureau Veritas (BV) | 35.6667 | 6.6239 | 25.267 | 2.971 |
| China Classification Society (CCS) | 4.3333 | 3.01109 | 2.733 | 0.475 |
| Croatia Register of Ship (CRS) | 0.933 | 0.51640 | 0.333 | 0.000 |
| Det Norsk Veritas (DNV) | 11.8333 | 12.12298 | 10.933 | 0.257 |
| Indian Register of Shipping | 2.3333 | 2.06559 | 0.533 | 0.514 |
| International Naval Survey Bureau (INSB) | 3.0000 | 4.64758 | 4.800 | -0.514 |
| International Register of Ships (IRS) | 1.3333 | 1.21106 | -0.467 | 0.514 |
| Germanischer Lloyds (GL) | 4.0000 | 3.68782 | 8.400 | -1.257 |
| Korea Classification Society (KCS) | 0.3333 | 0.51640 | 1.133 | -0.229 |
| Korea Register of Ships (KRS) | 2.3333 | 1.21106 | 1.133 | 0.343 |
| Lloyds Register of Ships (LR) | 27.1667 | 8.88632 | 12.067 | 4.314 |
| Polski Register Statkow (PRS) | 0.3333 | 0.51640 | 0.333 | 0.000 |
| Panama Maritime Documentation Services (PMDS) | 0.0000 | 0.00000 | 0.0000 | 0.00000 |
| Panama Register Corporation (PRC) | 0.5000 | 0.83666 | 0.600 | -0.029 |
| Recistro Italiano Navae (RINA) | 6.8333 | 3.12517 | 3.733 | 0.886 |
| Russian Maritime Register of Shipping (RMRS) | 4.0000 | 1.89737 | 4.600 | -0.171 |
| Nippon Kaiji Kyokai (NKK) | 33.8333 | 13.64429 | 12.333 | 6.143 |
| Vietnamese Register of Shipping (VRS) | 0.0000 | 0.00000 | 0.0000 | 0.00000 |
| Turkish Lloyds (TL) | 0.6667 | 0.51640 | 0.067 | 0.171 |
| Others | 2.3333 | 1.21106 | 1.533 | 0.229 |

Source: authors' calculation.

It is important to note that deficient ships represent ships that show default lapses in IMO regulations and the maritime safety rules, regulations, and standards which classification societies uphold. The results of **Table 2** indicate that the mean number of vessels that have deficiency in maritime safety regulations and standards, inspected in the jurisdiction of the Abuja MoU on PSC per annum, classed and certified by the American Bureau of Shipping (ABS), Bureau Veritas (BV), China Classification Society (CCS), Croatia Register of Ships (CRS), Det Norsk Veritas (DNV), Indian Register of Shipping, and International Naval Survey Bureau (INSB) is 25.50, 35.67, 4.33, 0.933, 11.83, 2.33, and 3.00, respectively, with respective standard deviations of 4.89, 6.63, 3.02, 0.52, 12.13, 2.07, and 4.65. Similarly, the mean number of vessels with deficiency in maritime safety standards, classed and certified by the International Register of Ships, Germanischer Lloyds (GL), Korea Classification Society (KCS), Korea Register of Ships (KRS), Lloyds Register of Ships (LR), Polski Register Statkow (PRS), and Panama Maritime Documentation Service (PMDS), inspected in the jurisdiction of the Abuja MoU on PSC between 2015 and 2020, is 1.33, 4.00, 0.33, 2.33, 27.17, 0.33, and 0.00, with respective standard deviations of 1.21, 3.69, 0.57, 1.21, 8.89, 0.52,

and 0.000. The Panama Register Corporation (PRC), Registro Italiano Navae (RINA), Russian Maritime Register of Shipping (RMRS), Nippon Kaiji Kyokai (NKK), Vietnamese Register of Shipping (VRS), Turkish Lloyds (TL), and others (other classification societies not individually identified in **Table 1**) have respective mean scores of deficient vessels of 0.50, 6.83, 4.00, 33.83, 0.00, 0.67, and 2.33, with respective standard deviations of 0.84, 3.13, 1.89, 13.65, 0.000, 0.52, and 1.21. The results indicate that vessels certified and classed by Bureau Veritas, with a mean deficiency score of 35.67 per annum, dominate deficient vessels trading in the jurisdiction of the Abuj MoU on PSC. This is followed by vessels certified and classed by Nippon Kaiji Kyokai (NKK), Lloyds Register of Ships (LR), and American Bureau of Shipping (ABS), with respective mean deficiency scores of 33.83, 27.16, and 25.50. **Figure 3**, below, shows the ranking of the identified classified societies in decreasing order of average number of ships with deficiency in safety rules, regulations, and standards in the Abuja MoU on PSC. This is similar to the findings of Yang and Yin (2018), who observed disproportionate deficiency levels for vessels classified by individual classification societies operating in various PSC MoU regimes.

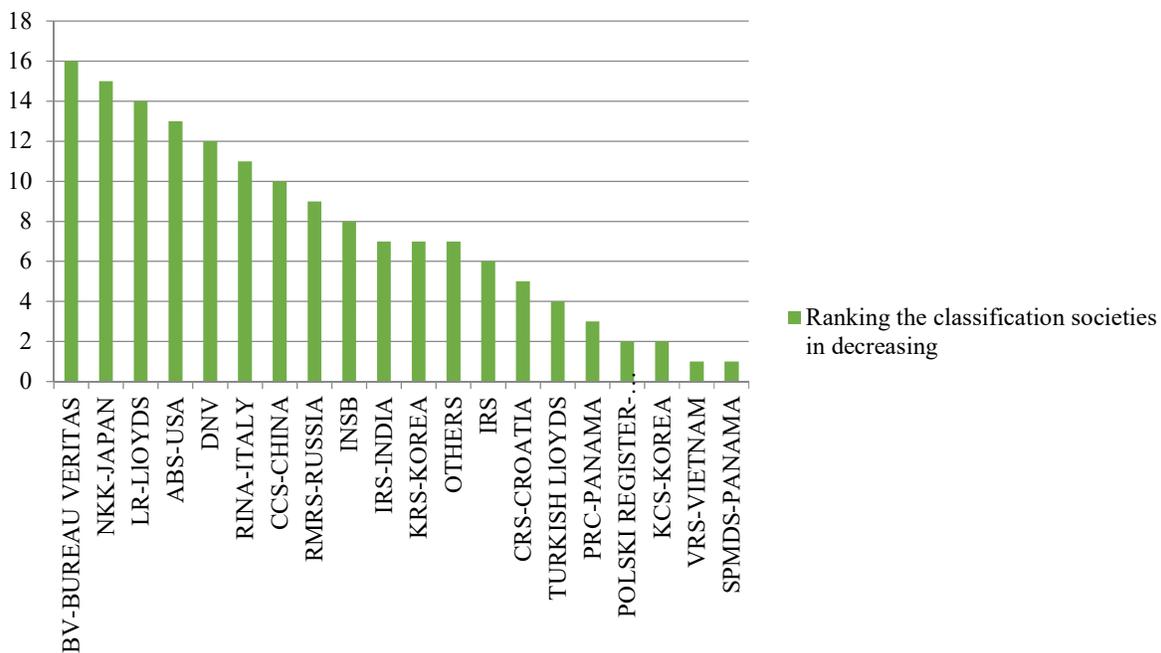


Figure 3 Ranking the classification societies in decreasing order of deficiencies in safety standards. Source: prepared by authors.

Table 2 also shows that the average rate of change coefficients of deficient ships inspected in the Abuja PSC regime classed and certified by the America Bureau of Shipping (ABS), Bureau Veritas (BV), China Classification Society (CCS), Croatia Register of Ships (CRS), Det Norsk Veritas (DNV), Indian Register of Shipping, and International Naval Survey Bureau (INSB) is 1.114, 2.971, 0.475, 0.000, 0.257, 0.514 and -0.514, respectively.

Similarly, the average rate of change coefficient of deficient ships inspected in the Abuja PSC regime, classed and certified by the International Register of Ships, Germanischer Lloyds (GL), Korea Classification Society (KCS), Korea Register of Ships (KRS), Lloyds Register of Ships (LR), Polski Register Statkow (PRS) and Panama Maritime Documentation Service (PMDS) is 0.514, -1.257, -0.229, 0.343, 4.314, 0.000, and 0.000, respectively.

Moreover, deficient ships classed and certified by the Panama Register Corporation (PRC), Registro Italiano Navae (RINA), Russian Maritime Register of Shipping (RMRS), Nippon Kaiji Kyokai (NKK), Vietnamese Register of Shipping (VRS), Turkish Lloyds (TL), and others (other

classification societies not individually identified in **Table 1**) have respective average rate of change coefficients of -0.029, 0.886, -0.171, 6.143, 0.000, 0.171, and 0.229. The implication is that, while the trend of deficient ships in the jurisdiction of the Abuja MoU on PSC certified by the International Naval Survey Bureau (INSB), Germanischer Lloyds (GL), Korea Classification Society (KCS), Panama Register Corporation (PRC), and Russian Maritime Register of Shipping (RMRS) have negative coefficients of average rate of change, which indicates a decreasing trend in the number of deficient vessels within the jurisdiction of the Abuja MoU regime certified by each classification society, the rest of the classification societies have positive coefficients of average rate of change, indicating an increasing trend in the number of deficient vessels classed and registered by each.

The regression constant when related to the rate of change coefficient provides a trend equation that offers a basis for the projection of the number of deficient ships certified by each identified individual classification society inspected in the Abuja MoU on PSC. For example, the trend of deficient ships certified by the American Bureau of Shipping (ABS) inspected in Abuja MoU jurisdiction between 2015 and 2020 is:

$$ISP_{ABS} = 21.600 + 1.114t \quad (17)$$

Table 3 Average deficiency to inspection ratio (ADIR) for individual classification society between 2015 and 2020.

| Classification society | Average deficiency/inspection ratio (ADIR) |
|--|--|
| American Bureau of Shipping (ABS) | 0.085 |
| Bureau Veritas (BV) | 0.086 |
| China Classification Society (CCS) | 0.043 |
| Croatia Register of Ship (CRS) | 0.399 |
| Det Norsk Veritas (DNV) | 0.137 |
| Indian Register of Shipping | 0.368 |
| International Naval Survey Bureau (INSB) | 0.205 |
| International Register of Ships (IRS) | 0.421 |
| Germanischer Lloyds (GL) | 0.034 |
| Korea Classification Society (KCS) | 0.333 |
| Korea Register of Ships (KRS) | 0.043 |
| Lloyds Register of Ships (LR) | 0.070 |
| Polski Register Statkow (PRS) | 0.057 |
| Panama Register Corporation (PRC) | 0.375 |
| Recistro Italiano Navae (RINA) | 0.058 |
| Russian Maritime Register of Shipping (RMRS) | 0.105 |
| Nippon Kaiji Kyokai (NKK) | 0.068 |
| Turkish Lloyds (TL) | 0.182 |
| Others | 0.250 |

Source: authors' calculation

In a similar manner, the trends of deficient ships certified by the various classification societies in the Abuja MoU regime can be determined. Though it is evident from **Table 2** that

vessels classed and certified by Bureau Veritas (BV) dominate the number of vessels with deficiency in safety rules, regulations, and standards in the Abuja MoU regime between 2015 and 2020, this does not imply wholly that BV constitutes the worst performer with regards to ships having deficiency in safety standards, given the disproportionate number of ships certified by the classification societies inspected in the Abuja MoU on PSC. To understand better the performance of each classification society with regards to deficient ships certified by them, it is best to also examine the quantum of ships certified by each classification society in the Abuja MoU regime, such that mean deficiency to mean inspection ratio is estimated and made the basis for further decision making on the safety performance of each classification society. **Table 3**, shows the average deficiency to inspection ratio (ADIR) for the identified individual classification societies between 2015 and 2020.

Table 3, shows the results of the average deficiency/inspection ratio (ADIR) for individual classification societies identified in the study. The ADIR shows the ratio of average number of ships classed and certified by each classification society that are found to be deficient in the Abuja MoU regime to the average number of vessels inspected in the jurisdiction of the Abuja MoU on PSC per annum between 2015 and 2020. The ADIR exposes, or brings to the forefront, the propensity/likelihood of a unit/single vessel certified by a given individual classification society having deficiency in compliance with safety standards and regulations. The results indicate ADIRs of 0.085, 0.086, 0.043, 0.399, 0.137, 0.368, and 0.205 for American Bureau of Shipping (ABS), Bureau Veritas (BV), China Classification Society (CCS), Croatia Register of Ships (CRS), Det Norsk Veritas (DNV), Indian Register of Shipping (IRS), and International Naval Survey Bureau (INSB), respectively. This implies that, for a unit ship classed and certified by ABS inspected in the Abuja MoU regime, there is approximately an 8.5 % likelihood that a deficiency in compliance with safety regulations and standards will be identified. There also exist approximately 8.6, 4.3, 39.9, 13.7, 36.8, and 20.5 % likelihoods of identifying deficiencies in compliance with safety regulations and standards for each unit of vessels certified and classed by Bureau Veritas, China Classification Society, Croatia Register of Ships, Det Norsk Veritas, Indian Register of Shipping, and the International Naval Survey Bureau, respectively.

Similarly, for each single vessel inspected in the Abuja MoU on PSC classed and certified by the International Register of Ships, Germanischer Lloyds (GL), Korea Classification Society (KCS), Korea Register of Ships (KRS), Lloyds Register of Ships (LR), Polski Register Statkow, and Panama Register Corporation (PRC), there are, respectively, 42.1, 3.4, 33.3, 4.3, 7, 5.7, and 37.5 %, likelihoods of recording deficiencies in compliance with safety regulations and standards. Vessels classed and certified by Registro Italiano Navae (RINA), Russian Maritime Register of Shipping (RMRS), Nippon Kaiji Kyokai (NKK), Turkish Lloyds (TL), and others (other classification societies not individually identified in the study) have, respectively, 5.8, 10.5, 6.8, 18.2, and 25 % likelihoods of identification of deficiencies in compliance with standards maritime safety regulations and rules. Vessels classed by GL with ADIR of 0.034 (3.4 %) shows the least likelihood of having safety defaults and deficiencies when inspected. **Figure 4**, below, shows the ranking of the classification societies in decreasing order of likelihood of having defaults and deficiencies in compliance with maritime safety standards in the Abuja MoU on PSC over the period covered in the study. Although Yang and Yin (2018) did not extend their study to calculating the ADIR score for individual classification societies, their findings show the existence of disproportionate deficiency and detention levels for vessels classified by individual classification societies operating in various PSC MoU regimes. This is similar to the disproportionate ADIR scores identified for ships classified by individual classification societies operating in the Abuja MoU on PSC.

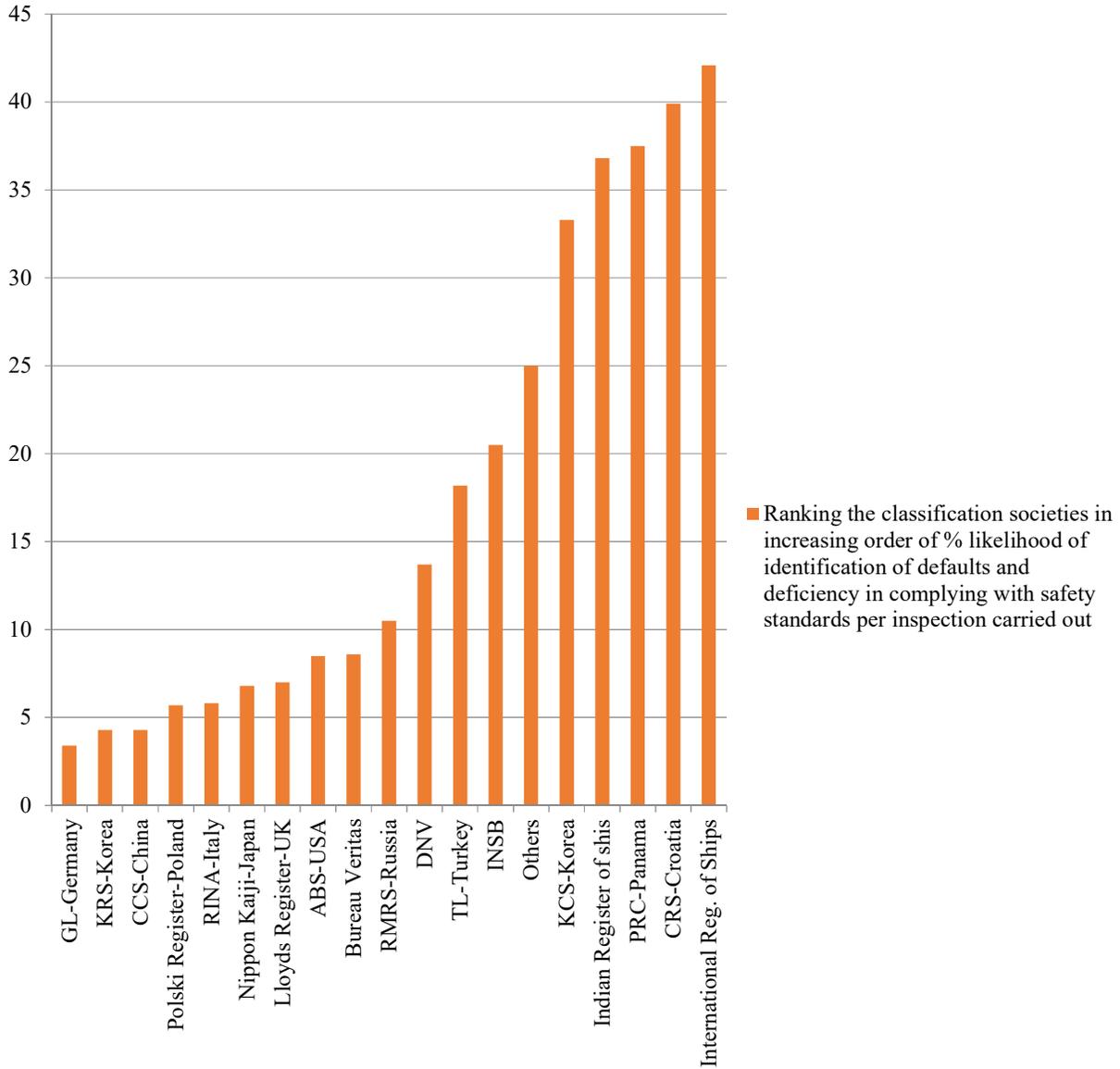


Figure 4 Ranking the classification societies in increasing order of % likelihood of identification of defaults and deficiency in complying with safety standards per inspection carried out.
 Source: prepared by authors.

The ranking indicates that the first ten (10) classification societies have their ADIRs between 0 and 10, which also indicates that % likelihood of deficient outcomes between 0 and 10 % dominate the choice of classification society by ship-owners operating in the Abuja MoU maritime jurisdiction. Though Det Norsk Veritas also shows high acceptance by ship owners in the region, it shows a percentage likelihood of deficiency of about 13.7 %, and represents the next best preferred classification society after GL-Germany, KRS-Korea, CCS-China, Polski Register Statkow, RINA-Italy, Nippon Kaiji Kyokai-Japan, ABS-USA, Bureau Veritas, and RMRS-Russia, which represent the best performers, as shown in **Tables 3** and **4**. See the results in **Table 4**, below, for empirical evidence of detention records of vessels classed by individual classification societies in the Abuja MoU on PSC regime.

Table 4 Detention of deficient ships certified by individual classification societies in the Abuja MoU on PSC Jurisdiction between 2015 and 2020.

| Classification society | Mean score of detained vessels (DET_t) | Standard deviation | Regression constant | Rate of change Coefficient of $\frac{\partial DET_t}{\partial t}$ |
|---|--|--------------------|---------------------|---|
| American Bureau of Shipping (ABS) | 3.8333 | 2.78687 | 1.533 | 0.657 |
| Bureau Veritas (BV) | 3.8333 | 1.8854 | 1.523 | 0.500 |
| China Classification Society (CCS) | 0.3333 | 0.81650 | 0.933 | -0.171 |
| Croatia Register of Ship (CRS) | 0.0000 | 0.00000 | 0.0000 | 0.0000 |
| Det Norsk Veritas (DNV) | 0.8333 | 1.16905 | 0.333 | 0.143 |
| Indian Register of Shipping | 0.0000 | 0.00000 | 0.0000 | 0.0000 |
| International Naval Survey Bureau (INSB) | 0.3333 | 0.51640 | 0.533 | -0.057 |
| International Register of Ships (IRS) | 0.3333 | 0.51640 | 0.533 | -0.057 |
| Germanischer Lloyds (GL) | 0.1667 | 0.40825 | 0.467 | -0.086 |
| Korea Classification Society (KCS) | 0.0000 | 0.00000 | 0.0000 | 0.0000 |
| Korea Register of Ships (KRS) | 0.1667 | 0.40825 | -0.133 | 0.086 |
| Lloyds Register of Ships (LR) | 1.8333 | 2.31661 | 2.533 | -0.200 |
| Polski Register Statkow (PRS) | 0.0000 | 0.00000 | 0.0000 | 0.00000 |
| Panama Maritime Documentation Services (PMDS) | 0.0000 | 0.00000 | 0.0000 | 0.00000 |
| Panama Register Corporation (PRC) | 0.0000 | 0.00000 | 0.0000 | 0.00000 |
| Registro Italiano Navae (RINA) | 1.0000 | 0.89443 | 1.000 | 0.00000 |
| Russian Maritime Register of Shipping (RMRS) | 0.1667 | 0.40825 | 0.067 | 0.029 |
| Nippon Kaiji Kyokai (NKK) | 2.3333 | 1.36626 | 4.733 | -0.686 |
| Vietnamese Register of Shipping (VRS) | 0.0000 | 0.00000 | 0.0000 | 0.00000 |
| Turkish Lloyds (TL) | 0.1667 | 0.40825 | -0.333 | 0.143 |
| Others | 0.5000 | 0.54772 | 0.600 | -0.029 |

Source: authors' calculation.

Detained deficient ships represent ships that show defaults and noncompliance with IMO regulations and maritime safety rules, regulations, and standards, to the extent and manner that the seaworthiness of such ships is marred. Thus, such ships are detained by Ports State Control Officers (PSCOs) until the deficiencies are corrected, and seaworthiness is guaranteed, before they can sail out of the port. The results of **Table 4**, above, indicate that the mean scores of the number of vessels detained for noncompliance with maritime safety regulations and standards, inspected in the jurisdiction of the Abuja MoU on PSC per annum, classed and certified by the American Bureau of Shipping (ABS), Bureau Veritas (BV), China Classification Society (CCS), Det Norsk Veritas (DNV), and International Naval Survey Bureau (INSB) is 3.8333, 3.8333, 0.833, 1.16905, and 0.333, respectively, with respective standard deviations of 2.78687, 1.8854, 0.817, 1.16905, and 0.516. Similarly, the mean number of vessels detained for reasons of compromised seaworthiness and deficiency in maritime safety standards, classed and certified by the International Register of Ships, Germanischer Lloyds (GL), Korea Register of Ships (KRS), Lloyds Register of Ships (LR), Registro Italiano Navae (RINA), and Nippon Kaijai Kyokai (NKK) inspected in the jurisdiction of the Abuja MoU on PSC between 2015 and 2020 is 0.3333, 0.1667, 0.1667, 1.8333, 1.000 and 2.333, respectively, with respective standard deviations of 0.51640, 0.40825, 0.40825, 2.31661, 0.89443, and 1.366. The Russian Maritime Register of Shipping (RMRS), Turkish Lloyds (TL), and others (other classification societies not individually identified in **Table 4**) have respective mean vessel detention scores of 0.1667, 0.1667, and 0.5000, with respective standard deviations of 0.4083, 0.4083, and 0.54772. The results indicate that vessels certified and classed by American Bureau of Shipping (ABS) and Bureau Veritas (BV), each with a mean detention score of 3.833 per

annum, dominate vessels detained for deficiencies that compromised seaworthiness in the jurisdiction of the Abuja MoU on PSC. This is followed by vessels certified and classed by Nippon Kaiji Kyokai (NKK), with a mean detention score of 2.333.

Figure 5, below, shows the ranking of the individual classified societies in decreasing order of average number of ships detained for deficiencies that marred seaworthiness in the Abuja MoU on PSC.

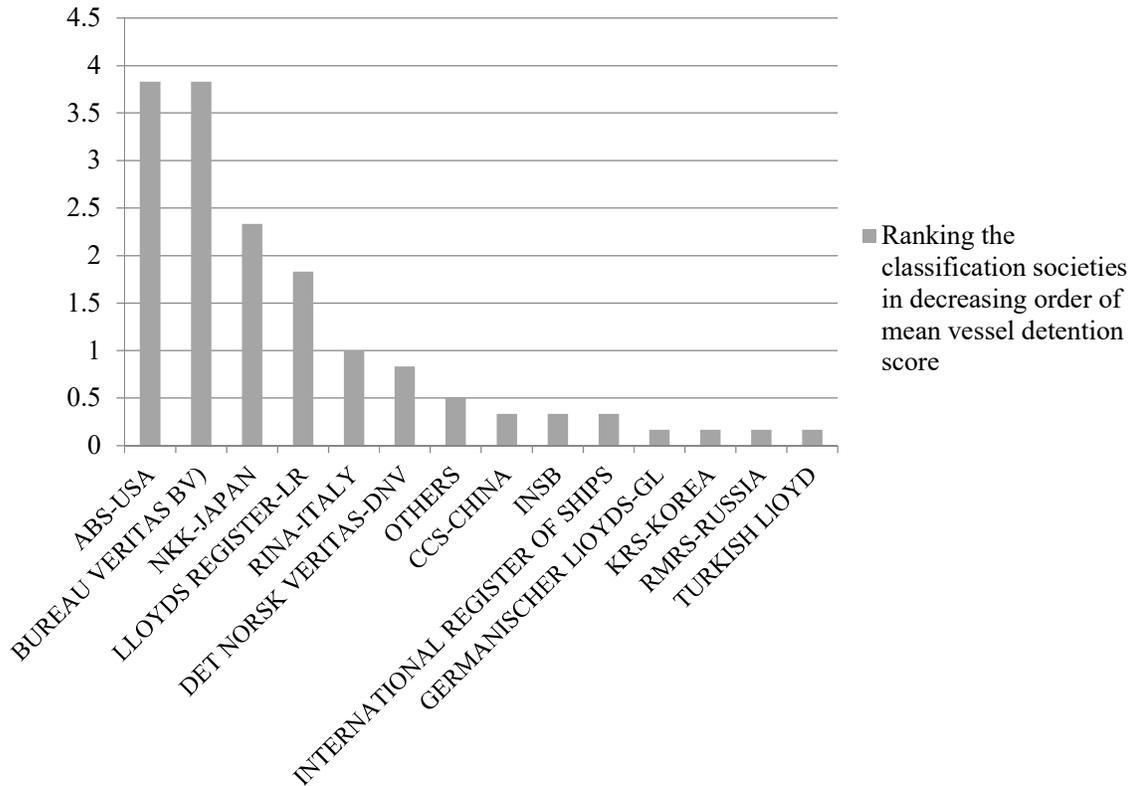


Figure 5 Ranking the classification societies in decreasing order of mean vessel detention score. Source: prepared by authors.

Table 4 also shows that the average rate of change coefficients of detained ships inspected in the Abuja PSC regime classed and certified by the America Bureau of Shipping (ABS), Bureau Veritas (BV), China Classification Society (CCS), Det Norsk Veritas (DNV), International Naval Survey Bureau (INSB), and International Register of Ships (IRS) is 0.657, 0.500, -0.171, 0.143, -0.057, and -0.057, respectively.

Similarly, the average rate of change coefficient of ship detention trend in the Abuja PSC regime for ships classed and certified by Germanischer Lloyds (GL), Korea Register of Ships (KRS), Lloyds Register of Ships (LR), and RMRS-Russia is -0.086, 0.086, -0.200, and 0.029, respectively.

Moreover, detained ships with marred seaworthiness classed and certified by Nippon Kaiji Kyokai (NKK), Turkish Lloyds (TL), and others (other classification societies not individually identified in **Table 4** above) have respective average rate of change coefficients of -0.686, 0.143, and -0.029.

The implication is that, while the trend of ship detention as a result of compromised seaworthiness in the jurisdiction of the Abuja MoU on PSC for vessels certified by the International

Naval Survey Bureau (INSB), CCS-China, Germanischer Lloyds (GL), International Register of Ships, Lloyds Register of Ships (LR), and NKK-Japan have negative coefficients of average rate of change, which indicates a decreasing trend in number of vessels detained between 2015 and 2020 for compromised seaworthiness in the jurisdiction of the Abuja MoU regime, the rest of the classification societies, with positive coefficients of average rate of change, show an increasing trend.

Though it is evident from **Table 4** that vessels classed and certified by ABS and Bureau Veritas (BV) dominate the number of vessels detained for deficiencies that marred seaworthiness of those vessels in the Abuja MoU regime between 2015 and 2020, it does not imply wholly that ABS and BV constitute the worst performers with regards to ships having deficiencies leading to ship detention. This is, in view of the disproportionate quantity of ships classed by the individual classification societies, inspected in the Abuja MoU regime over the period. To understand better the performance of each classification society with regards to deficiencies leading to detention of ships certified by the,, it is best to also examine the quantum of ships certified by each classification society in the Abuja MoU regime, such that the mean detention to mean inspection ratio (MDIR) is estimated and made the basis for further decision making on the safety performance of each classification society. **Table 5**, below, shows the mean detention to inspection ratio (MDIR) for the individual classification societies between 2015 and 2020.

Table 5 Mean detention to inspection ratio (MDIR) for individual classification societies between 2015 and 2020.

| Classification society | Mean deficiency/inspection ratio (MDIR) | |
|--|---|-------|
| American Bureau of Shipping (ABS) | 0.012 | 1.2 % |
| Bureau Veritas (BV) | 0.009 | 0.9 % |
| China Classification Society (CCS) | 0.0032 | 0.3 % |
| Det Norsk Veritas (DNV) | 0.009 | 0.9 % |
| International Naval Survey Bureau (INSB) | 0.023 | 2.3 % |
| International Register of Ships (IRS) | 0.11 | 11 % |
| Germanischer Lloyds (GL) | 0.001 | 0.1 % |
| Korea Register of Ships (KRS) | 0.003 | 0.3 % |
| Lloyds Register of Ships (LR) | 0.005 | 0.5 % |
| Recistro Italiano Navae (RINA) | 0.009 | 0.9 % |
| Russian Maritime Register of Shipping (RMRS) | 0.004 | 0.4 % |
| Nippon Kaiji Kyokai (NKK) | 0.005 | 0.5 % |
| Turkish Lloyds (TL) | 0.04 | 4 % |
| Others | 0.05 | 5 % |

Source: authors' calculation.

Table 5, above, shows the results of the mean detention/inspection ratio (MDIR) for vessels certified by individual classification societies. The MDIR for ships classed and certified by each classification society provides the propensity/likelihood of a unit/single vessel certified by a given classification society being detained due to deficiencies in safety standards that marred seaworthiness. The result indicates MDIRs of 0.012, 0.009, 0.0032, 0.009, 0.023, and 0.11 for ABS, BV, CCS-China, DNV, INSB, and International Register of Ships, respectively.

This implies that, for a unit ship classed and certified by ABS inspected in the Abuja MoU regime, there is approximately a 1.2 % likelihood of detention of the ship by PSCOs occasioned by deficiencies that marred the seaworthiness of the vessel. There also exist about 0.9, 0.3, 0.9, 2.3, and 11 % likelihoods of detention of individual vessels classed and certified by BV, CCS-China,

DNV, INSB, and International Register of Ships (IRS), respectively, due to marred seaworthiness occasioned by deficiencies in safety standards in the Abuja MoU on PSC jurisdiction.

Similarly, per unit vessel inspected in the Abuja MoU on PSC classed and certified by Germanischer Lloyds (GL), Korea Register of Ships (KRS), Lloyds Register of Ships (LR), Registro Italiano Navae (RINA), Russian Maritime Register of Shipping (RMRS), Nippon Kaiji Kyokai (NKK), Turkish Lloyds (TL), and others (other classification societies not individually identified in the study) have respective likelihoods of detention of 0.1, 0.3, 0.5, 0.9, 0.4, 0.5, 4, and 5 %. Again, Germanischer Lloyds (GL), with an MDIR score of 0.001 (0.1 %), shows the least likelihood of having safety defaults and deficiencies that could mar seaworthiness and lead to vessel detention. **Figure 6**, below, shows the ranking of the classification societies in decreasing order of likelihood detention occasioned by deficiency in compliance with maritime safety standards in the Abuja MoU on PSC over the period covered in the study. Although previous studies, such as the works of Yang and Yin (2018), Yilmaz, (2020), and Osman et al. (2020) did not investigate the MDIR scores for ships classified by individual classification societies, the findings of this study corroborate available empirical evidence from their studies which indicates the existence of disproportionate detention levels for vessels classified by individual classification societies operating in various PSC MoU regimes.

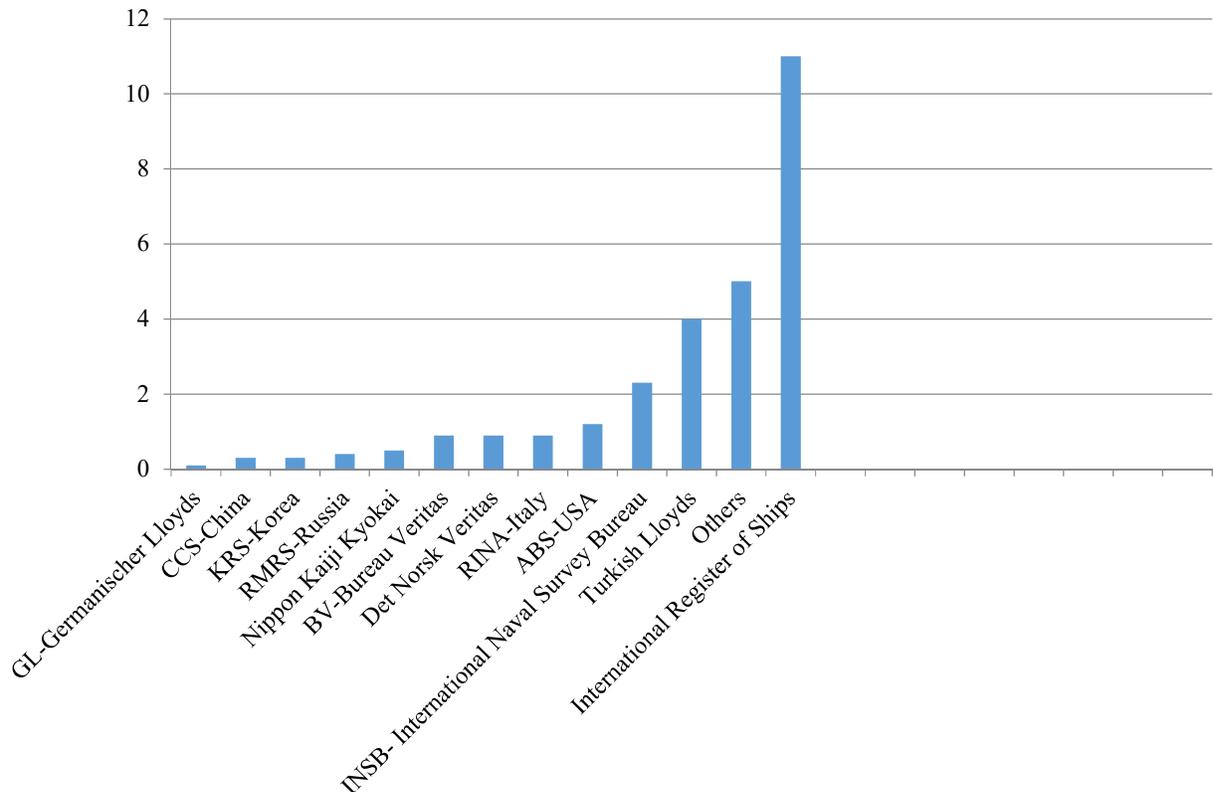


Figure 6 Ranking the classification societies in decreasing order of likelihood of detention of ships classified by each as a result of marred seaworthiness arising from safety deficiencies.

Source: prepared by authors.

The ranking indicates that the first ten (10) classification societies have their MDIRs between 0 and 1 %, approximately. The classification societies with MDIRs between 0 and 1 % likelihood of ship detention outcomes dominate the choice of classification society by ship-owners

operating in the Abuja MoU maritime jurisdiction. This implies Germanischer Lloyds, CCS-China, KRS-Korea, NNK-Japan, RMRS-Russia, Lloyds Register, London, Bureau Veritas, Det Norsk Veritas, ABS-USA, and RINA-Italy have better performance with regards to the likelihood of detention arising from marred seaworthiness in the Abuja MoU regime. Thus, they dominate ship-owners' preference for ship classification in West and Central African waters between 2015 and 2020.

4. Conclusions

Germanischer Lloyds, CCS-China, KRS-Korea, NNK-Japan, RMRS-Russia, Lloyds Register, London, Bureau Veritas, Det Norsk Veritas, ABS-USA, and RINA-Italy have better performance with regards to maritime safety in the Abuja MoU regime, as shown by the MDIR scores. Thus, they dominate ship-owners' preference for ship classification in West and Central African waters between 2015 and 2020, as shown in the ship inspection statistics of the Abuja MoU on PSC.

The trend of ship detention as a result of compromised seaworthiness in the jurisdiction of the Abuja MoU on PSC for vessels certified by the International Naval Survey Bureau (INSB), CCS-China, Germanischer Lloyds (GL), International Register of Ships, Lloyds Register of Ships (LR), and NKK-Japan have negative coefficients of average rate of change, which indicates a decreasing trend in number of vessels detained between 2015 and 2020 for compromised seaworthiness; the rest of the classification societies, with positive coefficients of average rate of change, show an increasing trend. Vessels classed by GL, with ADIR of 0.034 (3.4 %), show the least likelihood of having safety defaults and deficiencies when inspected.

The inspection data shows that ship-owners in the jurisdiction of the Abuja MoU on PSC show the highest preference for Nippon Kaiji Kyokai (NKK), more than any other classification society. This is followed by vessels certified by Bureau Veritas, with a mean inspection score of 413.0000, Lloyds Register of Ships (LR), with a mean inspection score of 387.67, American Bureau of Shipping (ABS), with a mean inspection score of 301.5000, and Germanischer Lloyds, with a 118.5000 mean inspection score. The preference of classification society by ship-owners, which is indicated by the mean number of vessels certified by each individual classification society inspected within the jurisdiction of the PSC MoU, has implications on the performance of vessels classed by each society with regards to maritime safety standards, rules, and regulations.

The future implications of the results and findings of the study are that it provides PSC inspectors in the Abuja MoU regime the basis for a better understanding of the performance of ships registered under individual classification societies operating in the jurisdiction of the Abuja MoU on PSC. This will help PSC inspectors to prioritize ships registered and classified by individual classification societies with the greatest rates of breaches of safety standards and regulations, while not losing sight on vessels registered by other classification societies. This will ensure improvement in maritime safety administration in the Abuja MoU jurisdiction in the long run. However, it is important to mention that a major limitation of the use of the results and findings of the study is that its application is limited to the Abuja MoU jurisdiction, since the data used in the study is limited to that of the countries in the Abuja MoU on PSC.

5. Recommendations

To achieve higher patronage from ship-owners, the performance of poorly-performing classification societies, with regards to upholding maritime safety standards, should be improved. This implies that classification societies with average deficiency to inspection ratios (ADIR) higher than 0.10 (10 %) should be reduced, while classification societies with mean detention to inspection ratios (MDIR) higher than 0.01 (1 %) should be reduced. This is achievable through strict implementation and compliance with maritime safety standards. Similarly, all classification societies, irrespective of current performance, must work to achieve negative coefficients of average

rate change for both deficiencies in compliance with safety standards and vessel detention rates. This will indicate improvement in levels of compliance with maritime safety regulations and standards for vessels trading in the Abuja MoU on PSC jurisdiction.

6. Suggestion for further research

As a way forward, it is suggested that similar, or the same, research be replicated and carried out in the other PSC MoU jurisdictions, in order that a comparison be made of the performance of individual classification societies in global waters and all maritime regions.

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