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Statistical analysis of maritime piracy cases in world territorial waters

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Abstract

In today's international trading system, most cargoes are transported by sea. In parallel with increasing trade volume, shipping trade and thus maritime traffic are also increasing. The smooth functioning of global trade depends on the safety of shipping trade routes. Given that ships may encounter dangers at sea, it is important to ensure their safety, particularly from piracy, which has become a global problem. Piracy occurs wherever shipping trade is intense while authority and control are weak. It is one of the most important problems threatening the maritime sector, especially due to financial crises, unemployment, high food prices, bribery, corruption, political instability, and inadequate surveillance and inspection. Today, navigation has become risky in many areas where piracy events are frequent, such as West and East Africa, the Strait of Malacca, and the South China Sea. Ships going to these areas take extra security measures or change their routes. Piracy adds extra costs, including ransom expenses, insurance expenses, route change costs, security expenses, and military measures. In addition, it causes billions of dollars of damage every year, results in deaths and serious injuries. While piracy can occur in territorial waters, international seas, or port areas, this study focused on piracy events in territorial waters since 2010, recorded in the International Maritime Organization (IMO) database. It analyzed these events statistically using frequency distribution before testing the hypotheses with Chi-Square analysis. Phi Cramer's V test was applied to determine the strength of the relationship between the hypotheses.

Keywords Maritime piracy · Chi-Square analysis · Phi Cramer's V test · Territorial waters · Shipping trade

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Introduction

Maritime transport is a key sector in international trade. Nowadays, around 50% of global trade in goods takes place between locations more than 2,000 miles apart, mainly using established international maritime trade routes. Thus, 80% of global trade goods are transported between ports worldwide by 50,000 merchant ships, crewed by over 1 million seafarers. These seafarers cross seas fraught with dangers, such as terrorism, local conflicts, and maritime piracy (UNCTAD 2014a; The State of Maritime Piracy 2017). The growth in the world economy has increased (World Bank 2021) in parallel with the global goods trade and maritime transport activities, which in turn has also increased maritime piracy (IMO 2021). Maritime piracy has long been a threat to maritime security, with historical records showing that it threatened Minoan maritime trade in the ancient eastern Mediterranean (Fu et al. 2010). Articles 100–110 of the United Nations Convention on the Law of the Sea (UNCLOS) are about maritime piracy. Maritime piracy is defined in Article 101 (UNCLOS 1982), although there are other definitions that are not directly legal:

(a) "any illegal acts of violence or detention, or any act of depredation, committed for private ends by the crew or the passengers of a private ship or a private aircraft, and directed:

  (i) on the high seas, against another ship or aircraft, or against persons or property on board such ship or aircraft;
  (ii) against a ship, aircraft, persons or property in a place outside the jurisdiction of any State;

(b) any act of voluntary participation in the operation of a ship or of an aircraft with knowledge of facts making it a pirate ship or aircraft;
(c) any act of inciting or of intentionally facilitating an act described in subparagraph *(a)* or *(b)*."

Thus, the definition includes various illegal acts within the scope of maritime piracy: kidnapping, hostage-taking, death, threat, attack, injury or loss for crew; unloading of weapons on the ship or perpetrators' equipment and goods for the ship; and theft or damage to the cargo (ICC-IMB 2020).

Researchers generally accept that maritime piracy events are initiated by individuals suffering economic problems and consequently dissatisfied with authority. They therefore seek alternative ways to achieve their economic objectives and improve their economic situation. Piracy often takes place on important trade routes between global economic powerhouses and poses a significant risk to maritime trade in important commodities including raw materials, energy products, and high-value manufactured products. Piracy is most frequent in the Gulf of Aden and the Strait of Malacca, which are two geographically limited but strategically vital waterways. They have become vulnerable to maritime pirate attacks as increased maritime

traffic has coincided with political and economic problems in each region. Other hot spots for piracy include Somalia in East Africa, the Gulf of Guinea in West Africa, and the Philippines in the South China Sea (Worrall 2000; Nincic 2002; Glavovic and Boonzaier 2007; Bird et al. 2008; Hastings 2009; Fu et al. 2010; Hong and Ng 2010). According to IMO reports, there has been an extraordinary increase in maritime piracy attacks globally in the last 30 years. Between 1995 and 2011, maritime piracy increased by 322% to a peak of 578 incidents, although it then decreased by 60% between 2011 and 2020 (IMO 2021).

While maritime piracy may also be ideologically and politically motivated, research suggests economic incentives are key (Fu et al. 2010). According to Murphy (2009; 2011), there are seven main factors increasing maritime piracy attacks. The most important is insufficient security. Second, disputed seawaters like the South China Sea create legal and jurisdictional openings. The remain factors include favorable geography, conflict and disorder in coastal countries, permissive political environments, maritime tradition, and rewards that outweigh the risk. Pirates also take advantage of judicial constraints, lack of ship self-protection, and widespread use of technology.

Growing piracy also imposes burdens on the global economy. Although the overall loss from piracy is quite small in relation to the total value of goods transported by sea, has considerable ripple effects on many countries (Khondaker et al. 2013). Global trade has fallen due to maritime piracy attacks while maritime piracy has increased costs through the ripple effect (Jones 2014). Although reports vary on the costs of maritime piracy, it clearly has several significant consequences in terms of both costs and trade. The global annual cost of maritime piracy is estimated at 1–16 billion USD annually. These costs can be classified into two groups: first order costs (deterrent security equipment and armed guards insurance, increased ship speed, shipping networks, and ship rerouting, ransoms, loss of earnings, naval forces, piracy-deterrence organizations, piracy prosecutions, and additional labor); and second order costs (transport and transit costs in geographically disadvantaged countries, ports in regions affected by piracy, global and regional trade, tourism, fisheries, food security and food price inflation, energy production, prices and security, environmental pollution, weather and climate-related data collection, and submarine installations) (UNCTAD 2014a, b).

Understanding the causes of maritime piracy activities is essential. This is important for understanding the true cost of maritime piracy. Maritime piracy acts should not be thought of as just ships being attacked as they have other primary and secondary effects (UNCTAD 2014a, b). Accordingly, the present study statistically examined the effects on maritime trade of shipping piracy incidents in territorial waters. The hypotheses defined were obtained from the IMO database between 2010–2021, and were investigated using Pearson Chi-Square tests. More specifically, this study examined the negative effects of the hypothesis results on maritime trade. After the hypothesis tests, Phi Cramer's V test was applied to determine the strength of the relationship between hypotheses that have a significant relationship between them. Thus, this study contributes to the literature by considering a wide range of data on maritime piracy incidents worldwide.

Literature review

Although piracy is believed to be as old as maritime history, the first recorded pirates were the Thracians, based on the island of Lemnos. The oldest documents regarding piracy date back to the thirteenth century BC, referring to the Sea Peoples, who threatened ships in the Aegean and Mediterranean (Tabanlı 2015). Piracy remains an important issue as it continues in many regions today with important consequences for human, economic, political, and potentially environmental security (Chalk 2012). It is therefore important to identify these problems and develop solutions, both in sectoral and academic terms. Many large-scale studies of piracy have been conducted from various perspectives: risk analysis (Liwång et al. 2013; Yang et al. 2013, Townsley and Oliveira 2015; Bouejla et al. 2014); statistical analysis (Wong and Yip 2012; von Hoesslin 2012; Vespe, et al. 2015; Coggins 2012; Tominaga 2018; Robitaille 2020; Pristrom et al. 2013; Morabito and Sergi 2018); historical analysis (Duman 2021); legal evaluations (Nwokedi et al 2020; Van Hespen 2016; Teo 2007; Rosenberg and Chung 2008).

Regarding statistical analyses, Wong and Yip (2012) used binary models to analyze piracy attacks from 2002 to 2009 using ICC International Maritime Bureau data for ship type, flag, ship operation, number of piracies, boarding methods, and arms type. The results indicated three major approaches for attacks, associated with differing levels of violence, arms used, and targets. Regan (2020) used nonprobability sampling to analyze piracy cases between 1985 and 2018 in 11 countries based on data from various organizations reporting piracy cases. The key predictors of piracy frequency were total country population, total fish tonnage, gross domestic product, and government weakness. Coggins (2012) examined piracy cases in 147 coastal countries between 2000 and 2009. The findings indicated an inverse relationship between piracy success rates and distance from land since successful attacks are generally concentrated in narrow waterways. In addition, piracy success rates, especially in the Gulf of Aden, decreased following increased international efforts to prevent maritime piracy after 2008. Nwachukwu et al. (2020) used regression analysis to investigate the relationship between piracy events in the Niger delta and the Niger's economy in terms of demographic characteristics. The findings indicated that piracy causes significant economic damage in the Niger delta in terms of economic development, transportation performance, and job creation. Given that piracy seriously hinders regional economic development, an intense effort is needed to eliminate it. Erginer et al. (2019) analyzed the effect of dry bulk and tanker market freight rates on piracy attacks, specifically the statistical relationship between the Baltic Dry Cargo Index and Baltic Dirty Tanker Index values and pirate attacks. Granger causality tests confirmed that freight rates determined the frequency of pirate attacks while regression analysis showed that changes in freight rates affected the number of pirate attacks. Ofosu-Boateng, (2018) used input–output analysis, correlation analysis, a fixed effects model, and chi-square tests to examine the piracy states in the Gulf of Guinea. The findings indicated that, in the long term, piracy attacks had no effect on the liner shipping connectivity index, gross domestic product

growth rate, and exports as a percentage of gross domestic product. However, on a country basis, there was a significant relationship between piracy and oil production in the Gulf of Guinea, although piracy attacks had no effect on oil production in the long term.

Vespe et al. (2015) statistically analyzed the impact of piracy on shipping routes in the Indian Ocean using Long Range Identification and Tracking (LRIT). The results confirmed the effectiveness of counter-piracy efforts. The LRIT data for statistical maritime traffic also enabled estimation of the extra fuel consumption due to the piracy. von Hoesslin (2012) investigated the effects on piracy and armed robbery in the Singapore Strait and the southern South China Sea of seasons, trends, modus operandi, and responsible criminal organizations. There were significant relationships between frequency of piracy attacks and season and geographic area. Lewis (2016) focused on the factors that determine the outcome of the confrontation when a ship is engaged by pirates. The findings indicate that observable action by a ship's crew is extremely effective in reducing the risk of the ship being successfully robbed or hijacked.

Researchers have used various models to examine maritime piracy cases. Varol and Gunal (2015) proposed a simulation model of piracy in the Gulf of Aden that consisted of discrete event simulation and agent-based simulation. Pirates, maritime transporters, and naval forces were included as stakeholders. The results demonstrated a causal relationship between naval forces and piracy prevention while the main prevention method was to have an onboard helicopter. Vaněk et al. (2013) developed AGENTC, a data-driven agent-based simulation model for maritime traffic, which explicitly models pirate activity and piracy countermeasures. The simulation results indicated that authorities designing corridor systems in the Indian Ocean should consider the positive contributions of past experiences in the Gulf of Aden. Bouejla et al. (2014) developed a prototype model for calculating hacking threats. This involves integrating a Bayesian network into the SARGOS system, which provides a warning report as input and a planning report as output. The study presented a list of different measures depending on the attack scenario and classified potential threats at three levels. After the threat has been identified and analyzed, a response plan is prepared by analyzing the necessary communication and procedures to address the current situation and its risks. Bensassi and Martínez-Zarzoso (2012) examined the effects of piracy events by applying the annual gravity model to exports from 27 EU countries to 21 destinations. The findings showed that dangerous maritime piracy, especially hijacking, reduces trade volumes with the relevant countries. More specifically, the elimination of piracy in the Gulf of Aden will slightly reduce maritime transport costs between Asia and Europe. However, the international community's measures will not abolish piracy but rather keep it under control. More specifically, two proto-states in the region (Puntland and Somaliland) mostly live off piracy. Therefore, strong support must be provided to one of the new Somali proto-states and a program implemented to retrain pirates as coast guards to fight the remaining pirates. Nwokedi et al. (2020) developed a historical design using the gross output and empirical probability models, and secondary data to determine output loss due to deaths and injuries from piracy cases. The findings indicated that pirate attacks in the Niger Delta Region's troll fishing

sector has seriously damaged Niger's economy, and caused many deaths and injuries. The attacks mostly involve kidnapping for ransom, which is very traumatic for the victims. To prevent this piracy, youth entrepreneurship and coastal development plans should be implemented while policies should be developed to prevent poverty among the young population.

The statistical analyses outlined above help determine the current situation regarding maritime piracy. However, it is also necessary to develop solutions. For this, it is essential to know the legal situation in the affected region in order to develop effective anti-piracy policies. Van Hespen (2016) investigated the application of the legal concept of "universal maritime crime" against maritime piracy in terms of UNCLOS. The findings indicated that there are some barriers due to jurisdictional issues, domestic criminal legislation, and human rights issues. Teo (2007) examined differences in how Singapore, Malaysia, and Indonesia fight against piracy in the Straits of Malacca. From, a wider perspective, Rosenberg and Chung (2008) studied the difference of maritime piracy security interests the gap between goals and means of achieving maritime security in coastal states bordering the South China Sea and international user states (Australia, India, Japan, and the United States). Poyraz and Tabanli (2018) examined the 2009 Djibouti code on piracy. They suggested that the states in the region will need help from the international community until they reach a sufficient level of prosperity. The main challenge is to encourage regional governments and organizations to take greater responsibility for ensuring simultaneous regional development and to create programs to improve the welfare of the Somali people. Kozanhan (2021) examined the Suppression of Unlawful Acts Convention (SUA) for terrorist attacks within the scope of piracy, specifically a judicial case under the scope of the SUA Convention. A Greenpeace action in 2013 against the Russian Federation's ship Arctic Sunrise and its oil platform Prirazlomnaya was evaluated within the scope of SUA. Under the protocol, Russian coast guard units boarded Greenpeace's ship to arrested activists and the ship's crew. The Arctic Sunrise's flag state, the Netherlands, was taken to court. In its decision dated 10 July 2017, the International Court of Arbitration found the Russian Federation guilty to the Dutch government of illegally detaining Greenpeace personnel. The court ruled that the Russian Federation's actions had not been carried out in accordance with the SUA Convention and its Additional Protocol (Kozanhan 2021).

Security and risk analyses are also important for countering maritime piracy. Yang et al. (2013) applied formal safety analysis (FSA) to evaluate maritime safety. Liwång et al. (2013) investigated maritime piracy in the Indian Ocean using questionnaires and interviews with civilian and military security experts. They used this data to conduct a risk analysis to identify effective risk control options. The findings indicated that the most important factor was developing a better understanding of the relationship between threat and risk. They also developed a scenario of the most important influences affecting the area. Oral and Şakar (2020) examined piracy cases in the Gulf of Guinea involving Turkish owners by interviewing eight participants working in companies owned by Turkish shipowners with ships operating in the region. Based on analysis of frequency and percentage distributions, security, economic, and personnel problems were identified in order to suggest solutions. The findings indicated that piracy in the Gulf of Guinea has made it the most dangerous

shipping area. The survey indicated that the most important preventive measure is the use of privately contracted armed security personnel (PCASP). In addition, ships entering the region need to take passive measures, considering that there are no naval elements belonging to international organizations or other countries unlike in the Gulf of Aden. Ships also need to prioritize either preventing pirate skiffs from approaching or leaving. The former is preferable for faster ships while the latter is preferred for slower ships. The interviews revealed that sector has been damaged by rising insurance costs due to piracy. In response, some companies avoided sailing to the region instead of paying kidnapping and ransom insurance. Ship crews were still working, although they were adversely affected by the attack. Türkistanlı and Kuleyin (2017) surveyed Turkish seafarers to investigate their responses to piracy and the use of PCASP. The participants regarded their presence as a positive measure while Turkish maritime companies preferred to work with such companies when operating in risky areas.

Alkan and Töz (2020) used interviews and a literature review to investigate the factors affecting the adaptation of PCASP working in areas experiencing piracy and the perceptions affecting them. A survey was used to measure the perception of the variables for employed persons at sea. One of the most important findings was that education level has a significant relationship with emotional and work conditions because individuals with a higher education expect better working and living conditions. PCASP with professional military backgrounds adapted more easily, especially in terms of work conditions and emotional conditions, because they were used to military discipline and a chain of command. There was also a significant relationship between of the mercenaries' combat experience and personality suitability. This is important in showing that PCASP, whose main duty is to use weapons, have personality traits that can be used without hesitation when necessary.

With respect to risk, Jin et al. (2019) proposed a model using binary logistic regression to estimate the probability of a ship being attacked based on data of maritime piracy attacks from 1994 to 2017. The analysis indicated that pirates are more likely to target small ships and open registry ships. In addition, boarding is more likely when a ship is berthed, at anchor, at night, in territorial waters and port areas, and in South America, the South China Sea, and the Strait of Malacca. Jiang and Lu (2020a) proposed a dynamic Bayesian network model to estimate dynamic emergency risk in sea lanes. Finally, Jiang and Lu (2020a) proposed an analytical model based on a Bayesian network to estimate the risk of a ship being attacked or hijacked.

To contribute further to this literature, the present study statistically examined the effects of maritime piracy incidents in territorial waters on shipping trade.

Application

Statistical analyses were performed on 863 maritime piracy cases, after removing missing data from World Territorial Waters between 2010 and 2020, compiled from the IMO GISIS (2021) website, using SPSS Statistics 21 package. First, the frequency and percentage distributions were calculated, then the hypotheses were

tested with Pearson Chi-Square analysis. To use this test, the theoretical percentage frequencies for each cell in the *rxc* tables and the Chi-Square independence test should be less than 20% (Çolak 2015). Some variables (ship type, flag group, region, crew result, weapon used, part of ship raided) were grouped. Table 1 – Table 2 presents the frequency and percentage distribution of piracy cases in territorial waters. Most cases occurred in the evening, night, or early morning. Cases predominantly occurred in the South China Sea, the Strait of Malacca, and West and East Africa. The largest annual increases occurred in 2011, 2014, and 2015. The distribution of attacks over months and days of the week is almost balanced. Most piracy attacks targeted tankers, followed by dry cargo ships. In total, 83.2% cases were correctly reported.

Table 3 shows the 30 hypotheses that were tested with Pearson Chi-Square analysis. These hypotheses test the significance of the relationships between weapon used, part of ship raided, consequence to the crew, and other criteria.

Table 4 shows the hypotheses test results. Regarding the weapon used, H_1, H_2, H_{10}, and H_{11} were accepted while H_3, H_4, H_5, H_6, H_7, H_8, and H_9 were rejected. Regarding the part of the ship raided, H_{12}, H_{13}, H_{15}, H_{16}, H_{17}, H_{18}, H_{19}, H_{20}, and H_{21} were accepted while H_{14} was rejected. Regarding the consequence to the crew, H_{22}, H_{25}, H_{26}, H_{27}, H_{28}, and H_{29} were accepted while H_{23}, H_{24}, and H_{30} were rejected. Thus, there is a significant relationship between the weapon used and the year, month, consequence to the crew, and part of the ship raided; between the part of the ship raided and the year, hour, ship type, ship condition, flag group, area, part of the reported, and consequence to the crew; and between consequence to the crew and year, hour, ship type, ship condition, flag group, and area. No significant relationships were found in the remaining hypotheses.

Phi Cramer's V test has used to measure the degree of relationship between the hypotheses that had a significant relationship as a result of the Chi-Square test. In this test, it is possible to determine the degree of relationship according to the results of Phi or V coefficient; the interpretation of these coefficients only depends on the significance of the chi-square value. In this context, the phi coefficient is a coefficient that measures the size of the relationship between two variables with two outcomes; It is calculated for 2×2 dimensional tables. For tables larger than 2×2, Cramer's V coefficient is used (Bölükbaşı and Yıldırtan 2009; Çolak and Ergün 2020). On the other hand, Rea & Parker (1992) determined Chamer's Phi or Cramer's V values as 0.00 and under 0.10 for "negligible association"; 0.10 and under 0.20 "weak association"; 0.20 and under 0.40 "moderate association"; 0.40 and under 0.60 "relatively strong association". They classified 0.60 and under 0.80 as "strong association" and 0.80 and under 1.0 as "very strong association" (Kotrlik et al. 2011).

In this context, we then applied the Phi Cramer's V test to determine the strength of the relationship between the hypotheses that had a significant relationship between them.

The following correlations were determined as a "weak association": H_1 $(v=0.176)$, H_2 $(v=0.166)$, and H_{11} $(v=0.177)$ while H_{10} $(v=0.378)$ was a "moderate association". Regarding H_{10}, weapons were used in 69.2% of "actual violence" situations and 56.5% of "threat of violence" situations. In contrast, guns were used in 25.8% of "none/not stated" cases That is, guns were more likely to be used as the

Table 1 Frequency and percentage distributions of maritime piracy cases in world territorial waters

	Frequency	Percent (%)
Year		
2010	70	8,1
2011	108	12,5
2012	73	8,5
2013	50	5,8
2014	115	13,3
2015	141	16,3
2016	43	5,0
2017	45	5,2
2018	78	9,0
2019	91	10,5
2020	49	5,7
Month		
January	84	9,7
February	86	10,0
March	59	6,8
April	90	10,4
May	77	8,9
June	51	5,9
July	47	5,4
August	74	8,6
September	48	5,6
October	82	9,5
November	84	9,7
December	81	9,4
Week Days		
Monday	111	12,9
Tuesday	95	11,0
Wednesday	130	15,1
Thursday	142	16,5
Friday	123	14,3
Saturday	140	16,2
Sunday	122	14,1
Hours		
00:00–04:00	316	36,6
04:01–08:00	219	25,4
08:01–12:00	63	7,3
12:01–16:00	55	6,4
16:01–20:00	73	8,5
20:01–23:59	137	15,9
Ship Type		
Dry Bulk	219	25,4
General Cargo	172	19,9

Table 1 (continued)

	Frequency	Percent (%)
Liquid Gas	23	2,7
Tanker	275	31,9
Other	174	20,2
Ship Status		
At Anchor	351	40,7
Steaming	432	50,1
Not Stated	80	9,3

Table 2 Frequency and percentage distributions of maritime piracy cases in world territorial waters (*continued*)

	Frequency	Percent (%)
Flag Group		
White List	688	79,7
Grey/Black List	53	6,2
Other	122	14,1
Area		
West/East Africa	173	20,0
Malacca Strait	253	29,3
South America	66	7,6
South China Sea	260	30,1
Indian Ocean	63	7,3
Other	48	5,6
Consequence to Crew		
Actual Violence	172	19,9
Thread of Violence	161	18,7
None/Not Stated	530	61,4
Weapon Used		
Yes	347	40,2
No/Not Stated	516	59,8
Reported		
True	718	83,2
False	145	16,8
Part of Ship Raided		
Engine Room	107	12,4
Main Deck	166	19,2
State Room	134	15,5
Not Boarded	145	16,8
Other	47	5,4
Not Stated	264	30,6

Table 3 Research hypotheses

Hypothesis	Statement
H_1	There is a significant relationship between weapon used and year
H_2	There is a significant relationship between weapon used and month
H_3	There is a significant relationship between weapon used and week days
H_4	There is a significant relationship between weapon used and hours
H_5	There is a significant relationship between weapon used and ship type
H_6	There is a significant relationship between weapon used and ship status
H_7	There is a significant relationship between weapon used and flag group
H_8	There is a significant relationship between weapon used and area
H_9	There is a significant relationship between weapon used and reported
H_{10}	There is a significant relationship between weapon used and consequence to crew
H_{11}	There is a significant relationship between weapon used and part of ship raided
H_{12}	There is a significant relationship between part of ship raided and year
H_{13}	There is a significant relationship between part of ship raided and month
H_{14}	There is a significant relationship between part of ship raided and week days
H_{15}	There is a significant relationship between part of ship raided and hours
H_{16}	There is a significant relationship between part of ship raided and ship type
H_{17}	There is a significant relationship between part of ship raided and ship status
H_{18}	There is a significant relationship between part of ship raided and flag group
H_{19}	There is a significant relationship between part of ship raided and area
H_{20}	There is a significant relationship between part of ship raided and reported
H_{21}	There is a significant relationship between part of ship raided and consequence to crew
H_{22}	There is a significant relationship between consequence to crew and year
H_{23}	There is a significant relationship between consequence to crew and month
H_{24}	There is a significant relationship between consequence to crew and week days
H_{25}	There is a significant relationship between consequence to crew and hours
H_{26}	There is a significant relationship between consequence to crew and ship type
H_{27}	There is a significant relationship between consequence to crew and ship status
H_{28}	There is a significant relationship between consequence to crew and flag group
H_{29}	There is a significant relationship between consequence to crew and area
H_{30}	There is a significant relationship between consequence to crew and reported

danger increased. The following correlations were determined as a "weak association": H_{13} *(v = 0,139)*, H_{15} *(v = 0,152)*, H_{18} *(v = 0,140)*, and H_{20} *(v = 0,139)* while H_{12} *(v = 0,351)*, H_{16} *(v = 0,202)*, H_{17} *(v = 0,243)*, H_{19} *(v = 0,237)*, and H_{21} *(v = 0,200)* had a "moderate association".

Regarding the relationship between year and piracy attacks (H_{12}), fewer than 3% of incidents involved the "engine room" in 2013. However, this suddenly increased to 21.5% in 2014 and 45% in 2015 before falling sharply below 3% in 2016 and reaching 7.5% in 2020. Similar percentages changes in location of attack were observed for "main deck", "not boarded", and "state room". Although significant changes were noticed, this is related to the amount of "not stated" and "other"

Table 4 Hypotheses test results

Hypothesis	Value	P	Result of Hypothesis
H_1	26,868	0,003	Accept
H_2	23,696	0,014	Accept
H_3	7,190	0,304	Reject
H_4	10,281	0,068	Reject
H_5	3,396	0,494	Reject
H_6	4,083	0,130	Reject
H_7	0,208	0,901	Reject
H_8	5,209	0,391	Reject
H_9	3,660	0,056	Reject
H_{10}	123,353	0,000	Accept
H_{11}	26,103	0,000	Accept
H_{12}	531,539	0,000	Accept
H_{13}	82,902	0,009	Accept
H_{14}	32,083	0,364	Reject
H_{15}	99,867	0,000	Accept
H_{16}	111,441	0,000	Accept
H_{17}	101,771	0,000	Accept
H_{18}	33,958	0,000	Accept
H_{19}	243,300	0,000	Accept
H_{20}	16,670	0,005	Accept
H_{21}	69,176	0,000	Accept
H_{22}	116,712	0,000	Accept
H_{23}	27,674	0,187	Reject
H_{24}	12,960	0,372	Reject
H_{25}	20,308	0,026	Accept
H_{26}	17,150	0,029	Accept
H_{27}	13,116	0,011	Accept
H_{28}	21,898	0,000	Accept
H_{29}	43,108	0,000	Accept
H_{30}	0,001	1,000	Reject

responses in the dataset. Regarding the part attacked, 46.8% of attacks targeted the "other" section for the category of "other" ships, 27.7% to general cargo ships. In all locations, tankers were most frequently attacked (H_{16}). Regarding the ship's position, 40.7% of attacks happened "at anchor", 50.1% while "steaming", and 9.3% were "not stated". When ships were steaming, the vast majority of attacks targeted the "engine room" (71.0%), "main deck" (56.6%), and "no boarded" (65.5%) whereas the "state room" was targeted most (63.4%) for ships at "anchor" (H_{17}).

The maritime regions with the most attacks were the South China Sea (30.1%) and the Malacca Strait (29.8%). In contrast, other seas (5.6%) and the Indian Ocean

(7.3%) were the least affected. In the South China Sea, most attacks (24.6%) targeted the "state room" and least (5.8%) "other" ship sections. In the Malacca Strait, most attacks targeted the "main deck" (39.2%) while the least targeted "other" Sects. (5.2%), (H_{19}).

With respect to the "part of ship raided", it is the "consequence to crew" attacks on "other", "actual violence" occurred the most, and "none/not stated" occurred the most in all the others (H_{21}).

H_{26} *(v=0,097)* and H_{27} *(v=0,087)* had a "negligible association";" H_{25} *(v=0,108)*, H_{28} *(v=0,133)*, and H_{29} *(v=0,158)* had a "weak association; while H_{22} *(v=0,260)* "moderate association". Regarding "consequence to crew", "none/not stated" remained around 50% until 2012 before it suddenly decreased in 2013 (28.0%). It then increased to 44.3% in 2014, 82.5% in 2016, and continued at 60–83% band in the following years.

This improvement in the situation in 2016 demonstrates the effectiveness of the information sharing mechanism of ReCAAP, and close cooperation between ReCAAP ISC, ReCAAP Focal Points, regional authorities, partner organizations, and the shipping community ((ReCAAP ISC) 2016). The importance of measures taken in the international arena had a great effect on the decrease (IMB PRC 2022) in maritime piracy activities in recent years (ICC International Maritime Bureau (IMB PRC) 2017a, b; (ReCAAP ISC) 2016). These measures included law enforcement and socio-economic initiatives, increased naval operations, the creation of an Internationally Recommended Transit Corridor (IRTC), the use of armed guards on vessels, anti-piracy campaigns, law implementation mechanisms, and the Djibouti Code of Conduct, the Global Maritime Crime Programme (GMCP), and Best Management Practices (BMP) (Gikonyo 2018). In the Gulf of Guinea, the increased presence of naval forces and cooperation between regional authorities reduced maritime piracy activities (Gard 2022). Since 2009, affected countries have sent naval escort fleets to the Gulf of Aden and participated in dramatically reducing the number of pirate attacks (Jiang and Lu 2020b).

Discussion and conclusion

Maritime piracy has been occurring for centuries and still continues to be a problem today. According to the IMO's maritime piracy database covering 1995–2021, maritime piracy generally occurs in international waters, territorial waters, and port areas. However, territorial waters and port areas are most at risk. Accordingly, this study statistically examined maritime piracy cases in territorial waters.

The study examined 863 maritime piracy cases in territorial waters between 2010 and 2020 using statistical analysis performed with SPSS program. After analyzing frequency and percentages distributions, 30 hypotheses were created to analyze the relationship of the factors with each other. Some variables were combined to ensure that fewer than 20% of cells had five. The hypotheses are tested using the Pearson chi-square test.

Regarding the frequency distributions, the number of cases increased from 70 in 2010 to 108 in 2011 before falling to 73 in 2012 and 50 in 2013. Cases more

than doubled in 2014 and continued to rise to 141 in 2015. There were 43 cases in 2016, 54 cases in 2017, and they increased in 2018 and 2019. Cases fell in 2020 to about half of 2019. Regarding months, fewer than 60 attacks occur in March, June, July, and September whereas over 70 attacks occur in other months. Case numbers are almost evenly distributed over the days of the week. Regarding time, 77.9% of attacks occurred between 8 p.m. and 8 a.m. Regarding ship types, 31.9% of attacks targeted tankers, 25.4% dry cargo ships, and only 2.7% targeted liquid gas ships. Regarding maritime region, 79.4% of cases occurred in the South China Sea, the Strait of Malacca, or East or West Africa. The most attacks were in the South China Sea and the Strait of Malacca. Regarding violence, 172 cases were reported as actual violence, 161 cases as violence, and 530 cases as "none/not stated". Weapons were definitely used in 40.2% of cases while 83.2% of cases were correctly reported.

Thirty hypotheses were created to test relationships between the weapon used, the part of the ship raided, and its consequences to the crew, year, day, time, ship type, ship condition, flag group, maritime area, and correct report. The Pearson chi square test results indicated significant relationships between weapon used and year, month, consequence to the crew, and part of the ship raided, between part of ship raided and year, hour, ship type, ship condition, flag group, area, reported and between consequences to crew and consequence to crew, and year, hour, ship type, ship condition, flag group, and maritime area. There were no significant relationships between weapon used and day, hour, ship type, ship status, flag group, maritime area and correct report, or between part of ship raided and day, or between consequence to the crew and month, day, and correct report.

H_2, H_{13}, H_{19}, and H_{29} were accepted. von Hoesslin (2012) also reported that piracy attacks are associated with season and geographic region in the Singapore Strait and South China Sea as the rainy season lasts from November to March, which makes it difficult to board ships due to strong winds and high swell. H_{16}, H_{17}, H_{18}, H_{26}, and H_{28} were accepted. Wong and Yip (2012) also reported a relationship between ship size and geographic region. However, ship flag is not generally a critical factor in piracy attacks as pirates with commercial objectives do not target specific flags. In contrast, flags may be a specific target for terrorism and political violence. Bigger ships are better protected than small ships. Pirates also target smaller ships because they have a lower freeboard and slower speed. Pirates tended to target container ships, bulk carriers, and tankers because of their perceived value and potential ransom value. Chemical and oil tankers have particularly low freeboards (Mejia et al. 2009; Shane and Magnuson 2016). Mejia et al. (2009) found a relationship between type of ship and registry flag in maritime piracy. Anchored and berthed ships are more vulnerable to attack than steaming ships. Bulk carriers, general cargo ships, container ships, chemical tankers, and tankers are favorite pirate targets (Wong and Yip 2012; Pristrom et al. (2013). Shortland (2012) argued that an effective response against maritime piracy requires the development and enforcement of the law. There should be a focus on relevant countries' problems to determine the source of piracy problems. Piracy attacks are likely to continue until the countries involved reach a certain level of stability and economic prosperity (Sergi and Morabito 2016).

In conclusion, the maritime piracy problem is highly complex, so there may be no single solution. This study conducted a statistical analysis of piracy in territorial waters between 2010 and 2020. Therefore, future studies could replicate this method in a wider range of years. Future studies could also focus on international waters and port areas, either separately or all regions can be studied together. Future studies could undertake risk analysis and management as the statistical analyses in the present study have revealed the status of maritime piracy in territorial waters between 2010 and 2022.

Author contributions Authors contributed to introduction, literature, conceptualization, methodology, writing and conclusion.

Data availability Not applicable.

Declarations

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Ethical approval This material is the authors' own original work, which has not been previously published elsewhere. The paper is not currently being considered for publication elsewhere. The paper reflects the authors' own research and analysis in a truthful and complete manner.

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