# Piracy defense strategies for shipping companies and ships: A mixed empirical approach

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ABSTRACT

Piracy attacks constitute a serious threat against which ships must be ready to defend themselves, particularly given the financial, political and logistical challenges involved in ensuring internationally coordinated protection. Yet, defense is highly challenging given the range of ship types, differing levels of government support, a constantly adapting pirate body, and pressures on costs and resources. Indeed, despite much guidance to deal with piracy, attacks continue unabated, and ships must defend themselves. To complement such guidance and suggest priorities for ship defense, this paper adopts a Fuzzy Analytic Hierarchy Process (FAHP) and in-depth interviews to identify key strategic criteria against piracy attacks. Questionnaire responses were from 14 shipping operators and 7 academics. Subsequently, highly experienced government officials (n=3) and shipping operators (n=3) were interviewed to provide additional depth and perspectives. Results show key criteria are international conventions and policy, followed by defense strategies in perilous water areas, and ship's hardware and software. Regarding implementation, it is suggested shipping companies take ownership of any measures introduced, and outlined how they can do so. Also, managerial implications for shipping companies, governments, international bodies and researchers are outlined.

## 1. Introduction

Maritime piracy is defined as any illegal act of violence or detention, or any act of depredation, committed for private ends by the crew or the passengers of a private ship based on Article 101 of the 1982 United Nation Convention on the Law of the Sea (UNCLOS)[1]. In recent years, maritime pirate attacks and armed robbery have evolved to become more organized, and international crime activities (e.g. Somali piracy (Kiourktsoglou and Coutroubis, 2012; Gikonyo, 2018)) have also been connected with terrorism (Hong and Ng, 2010; Wambua, 2012; Pristrom et al., 2013). Such a phenomenon has brought serious global problems and shipping economic loss (Gauci, 2012; Lambrou, 2012; Abila and Tang, 2014; Varol and Gunal, 2015; Tominaga, 2018). For example, one United States (US) study found the global economic cost of piracy to be between $7~12billion a year.[2] Also, piracy involves hostage taking, ransoming, human cost and mental health problems (e.g. Post-Traumatic Stress Disorder (PTSD)). Piracy is unfortunately an enduring issue, and despite attempts to prevent it, is resurgent, with a doubling in attacks from 2016 to 2017 off the horn of Africa (Africa News, 2018). In 2018, Witherby Publishing Group (2018) published "Best Management Practices to Deter Piracy and Enhance

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Maritime Security in the Red Sea, Gulf of Aden, Indian Ocean and Arabian Sea" to provide threat and risk assessment strategies and identify ship protection measures (e.g. hardening the ship, crew training, enhancing lookout, following flag state and military guidance) whilst sailing in piracy risk areas. Also, incident and suspicious activity report and cooperation with stakeholders (e.g. other shipping, military forces, welfare providers) are thoroughly outlined in these Best Management Practices. Yet, piracy attacks strategies are dynamic and not readily predictable, due to the fact that pirates are highly adaptable to how ship operators and masters defend their ships.

Solutions to piracy are challenging to implement, and often presented holistically in overall integrated international regulations and practical suggestions rather than specifically tailored for ships themselves. It is considered ideal to deal with piracy by improving the social conditions and welfare of the countries the pirates are from (Baniela and Rios, 2012). This however, is only possible through strong state aid, and if the example of Somalia is considered, it remains a major source of piracy, and is a 'stateless' country according to some (e.g. Baniela and Rios, 2012). Indeed, levels of corruption are so high in Somalia that in Transparency International's Corruption Perceptions Index of 2019 Somalia was ranked in last place at number 180 out of 180 (Transparency International, 2019). Furthermore, current laws mean it is often extremely challenging to reprimand, incarcerate, and then prosecute pirates (Pristrom et al., 2013). For example, once a vessel is boarded in an attack, the situation changes from one of piracy to a hostage/ransom situation (Fawcett, 2010). What is more, proceeding with legal prosecution of piracy often requires crew members to be absent from the ship for a lengthy period of time, and captains are reluctant to lose valuable crew members (Fawcett, 2010).
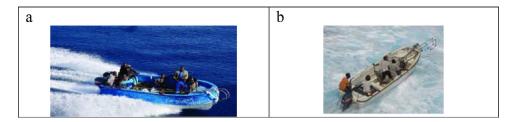
Ideally, naval protection could help ships, yet the investment required to ensure this is simply unfeasible. Both the areas and hotspots (Pristrom et al., 2013) or 'chokepoints' (Fu et al., 2010) of piracy that naval vessels would need to patrol are impractically extensive at 2.5 million square kilometers (Fawcett, 2010), and differing shipping schedules mean the optimum policy of naval assisted convoys (Fawcett, 2010) is impossible. Moreover, much research shows a correlation between economic hardship, and an increase in serious crime and piracy (Bateman, 2010). Notably, ship owners may have to cut costs and substandard ships may be used, which then become most vulnerable to piracy attacks (Bateman, 2011). Thus, although shipping companies have developed various strategic measures against pirates, such as crew security training, employment of armed guards on vessels from professional security companies, insurance, and so on (Phillips, 2009; Fu et al., 2010; Pristrom et al., 2013), attacks still happen. This situation continues regardless of International Maritime Organization (IMO) guidelines and international conventions and regulations. The extreme severity of piracy attacks is explicitly illustrated by the case of the Rak Afrikana. After pirates had hijacked the ship, the Captain was subjected to mental and physical torture, arguably leading to PTSD, and suffered from a brain hemorrhage and died shortly afterwards (Bateman, 2011).

For the Europe-Far Asia shipping trade, the Gulf of Aden is a key gateway for ships to access the Suez Canal. Otherwise, they must use the alternative route via the Cape of Good Hope at significant additional time and cost. However, the piracy threat near the Gulf of Aden has inevitably affected shipping companies' sailing decisions and schedules (Fawcett, 2010). On 23 March, 2021, one huge containership became locked in the Suez Canal[3] and as a result some Asia-Europe ships had to change their routes from the Suez Canal to around the Cape of Good Hope. These ships might face the risk of a piracy attack during their journey through the Gulf of Aden. According to the International Maritime Bureau[4], there were 195 incidents of piracy and armed robbery against ships worldwide in 2020. Past studies on piracy have focused on a wide range of aspects. For example: international law (Baniela and Rios, 2012), insurance (Tseng and Li, 2013; Tseng, 2014), regime type (Gikonyo, 2018), economic impact and human cost (Yang, 2010; Bateman, 2011), the impact of economic development (Fu et al., 2010), ship vulnerability (Bateman, 2010), and simulations of prevention operations (Varol and Gunal, 2015). Yet, research into any strategic evaluation of approaches to defense is still limited. This is critical, given the simultaneous need for ships to defend themselves against enduring pirate attacks, and the pressure to prioritize scarce resources and time to the optimum value. Highly valuable work has been undertaken in relation to many aspects of protection against piracy, For example, the technological ability to recognize the outlines of nearby ships (Szpak and Tapamo, 2011), risk management against piracy attacks (Sevillano, Rios Insua, and Rios, 2012), and the development of a ship's security plan (White and Wydajewski, 2002). Further, other papers have provided historical overviews regarding how to approach safety; and some have called for policy to align key guidelines, and to ensure more robust international guidelines (Boot, 2009; Kraska and Wilson, 2008; Struett, Nance and Armstrong, 2013).

To complement the existing literature, this paper identifies strategies for ships to prioritize in defense against piracy attacks. It does this based on a combination of a quantitative questionnaire survey and qualitative interviews. For the quantitative approach, the paper adopts a Fuzzy Analytic Hierarchy Process (FAHP) to overcome the traditional shortcomings of AHP. For example, (1) an FAHP improves the research limitation of assessment of vagueness when filling the questionnaire content and avoids overly crisp decision applications. (2) it offers a more effective dealing method to solve an unbalanced scale of judgment. (3) it can reduce subjective judgement and preference of decision-makers (Kabir and Hasin, 2011). The later qualitative stage aimed to gain a more nuanced and holistic overview of the quantitative results, and involved in-depth interviews with government officials and shipping operators. The two stages were treated separately (see Section 3.4 for more details) but their results are here discussed together and alongside each other. Participants in both the quantitative and qualitative stages were from Taiwan, and worked with, or worked for, international shipping companies sailing through these waters. The overall contribution of the research findings can be used by ships to prioritize strategies to protect themselves against potential pirate attacks, both in terms of prevention and in terms of action in the event of an

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[3] https://www.bbc.com/news/world-middle-east-56505413
[4] https://www.icc-ccs.org/index.php/1301-gulf-of-guinea-records-highest-ever-number-of-crew-kidnapped-in-2020-according-to-imb-s-annual-piracy-report

**Fig. 1.** (a) piracy boat; (b) piracy boat.
Source: Witherby Publishing Group (2011)

attack. The remainder of this paper is organized as follows: Section 2 reviews recent literature and data relating to piracy regarding the nature of attacks and approaches to defense. Section 3 details the methodology of the FAHP, including questionnaire measurement, respondents, the experts subsequently interviewed, and how these data were collected and analyzed. The results and analysis are presented in Section 4, and Section 5 discusses these results and identifies key priorities. These priorities are primarily targeted to shipping companies, but are also intended for consideration by governments, international bodies and researchers. Section 6 concludes the paper, drawing together the main themes and suggesting avenues for future research.

## 2. Literature Review

### 2.1. The statistics of maritime piracy attacks

Based on data from the International Maritime Bureau[5], Table 1 shows the number of piracy attacks during 2015~2019, and that the majority originate from Indonesia and Nigeria. The major piracy attack hotspots include the South China Sea, West Africa, and the Straits of Malacca and Singapore.[6] In order to reduce the threat of piracy in these areas, many anti-piracy efforts with air patrols have been implemented in the Straits of Malacca (Axbard, 2016), Somalia, and other areas.[7]

During 2015~2019, as Table 2 below shows, the major types of piracy attacks were 'boarding the ship', followed by 'attempted boarding', 'hijack' and 'being fired upon'. In general, these potential piracy attack situations are embedded in ship security plans for each shipping company and are based on the International Code for the Security of Ships and Port Facilities (ISPS) (Randic et al., 2015). The crews must regularly participate in education training aimed to reduce potential loss and damage (Hanninen and Kujala, 2014).

Regarding the types of violence towards the crew, during 2015-2019, 'Hostage' taking was the most used strategy by pirates, followed by 'Kidnap', 'Threats', 'Injured', 'Assaults', and 'Killed'. Arguably, pirates take hostages to obtain more negotiating power and to bargain for higher ransom money from ship owners or related units (e.g. insurance companies, government organizations) (Table 3). In total, the number of violent acts towards crew were 191~333 and the trend was one of decreasing in 2019, although as noted above (Africa News, 2018) these numbers may show an increase as more recent figures are released.

Regarding ship types, tanker chemistry/product and bulk carriers were more frequently attacked by pirates for the following reasons: (1) the speed of these vessels is quite slow compared to other types of vessels; and (2) they have a lower freeboard when laden (Bateman, 2010; Pristrom et al., 2013) (Table 4).

Commonly, when conducting attacks, pirates use two or more small high speed (up to 25 knots) boats, with AK 47 rifles and pistols, which are carefully coordinated to attack commercial ships (Vanek et al., 2013) (Fig. 1.). When approaching a commercial ship, pirates use long lightweight and hooked ladders to attempt to board.

In order to defend against pirate attacks, ships can be equipped with razor wire around the deck or use a water spray to block the pirate's boat. Also, since the bridge is analogous to the brain of the ship, steel bars are used to protect the bridge whilst sailing in high risk areas (Fig. 2).

### 2.2. Defense strategies criteria

There are many defence strategies used against pirate attacks. Based on past studies, here we summarize three criteria and 10 sub-criteria.

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[5] https://www.icc-ccs.org/icc/imb

[6] International Maritime Organization. http://www.imo.org/en/Pages/Default.aspx

[7] Past studies on piracy from Indonesia and Nigeria are scarce and most studies have focused on piracy from Somalia. One possible explanation is that the main area where Somali piracy attacks occur is located near a key shipping route between Asia and Europe and generates significant attention compared to Indonesia and Nigeria. Related studies can refer to Axbard (2016), Kiourktsoglou and Coutroubis (2012), Gikonyo (2018), Transparency International (2019). However, it is arguable that more studies into piracy from Nigeria and Indonesia would complement existing knowledge.

**Table 1**
Location of actual and attempted attacks (2015~2019).

| Location | | 2015 | 2016 | 2017 | 2018 | 2019 | Sub-total |
|---|---|---|---|---|---|---|---|
| S | Indonesia | 108 | 49 | 43 | 36 | 25 | 261 |
| E | Malacca Straits | 5 | – | – | – | – | 5 |
| Asia | Malaysia | 13 | 7 | 7 | 11 | 11 | 49 |
| | Philippines | 11 | 10 | 22 | 10 | 5 | 58 |
| | Singapore Straits | 9 | 2 | 4 | 3 | 12 | 30 |
| | Thailand | 1 | – | – | – | – | 1 |
| EAST | China | 4 | 7 | 2 | 3 | 3 | 19 |
| | Vietnam | 27 | 9 | 2 | 4 | 2 | 44 |
| INDIAN | Bangladesh | 11 | 3 | 7 | 12 | 0 | 33 |
| SUB CONT | India | 13 | 14 | 4 | 6 | 4 | 41 |
| AMERICAS | Brazil | – | – | – | 4 | 2 | 6 |
| | Colombia | 5 | 4 | 6 | 1 | 3 | 19 |
| | Dominican Republic | – | – | – | – | 1 | 1 |
| | Ecuador | – | – | 2 | 4 | 3 | 9 |
| | Guyana | – | 2 | 1 | 2 | – | 5 |
| | Haiti | 1 | 4 | 1 | 3 | 2 | 11 |
| | Mexico | – | 1 | – | – | 1 | 2 |
| | Panama | – | – | – | – | 1 | 1 |
| | Peru | | 11 | 2 | 4 | 10 | 27 |
| | Venezuela | 1 | 5 | 12 | 11 | 6 | 35 |
| AFRICA | Algeria | – | – | – | – | 1 | 1 |
| | Angola | – | 2 | 1 | 0 | 0 | 3 |
| | Benin | – | 1 | – | 5 | 3 | 9 |
| | Cameroon | 1 | – | – | 7 | 6 | 14 |
| | Democratic Rep. of Congo | 3 | 2 | – | 1 | 1 | 7 |
| | Egypt | 1 | – | – | – | – | 1 |
| | Equatorial Guinea | – | – | – | – | 2 | 2 |
| | Gabon | – | – | – | – | 1 | 1 |
| | Ghana | 2 | 3 | 1 | 10 | 3 | 19 |
| | Guinea | 3 | 3 | 2 | 3 | 2 | 13 |
| | Gulf of Aden* | – | 1 | 3 | 1 | – | 5 |
| | Ivory Coast | 1 | 1 | 1 | 1 | 1 | 5 |
| | Kenya | 2 | 2 | 1 | – | 1 | 6 |
| | Liberia | 2 | – | – | – | 2 | 4 |
| | Morocco | – | 1 | – | – | 2 | 3 |
| | Mozambique | 1 | 1 | 2 | 2 | 3 | 9 |
| | Nigeria | 14 | 36 | 33 | 48 | 35 | 166 |
| | Red Sea* | – | – | 1 | – | – | 1 |
| | Senegal | – | – | 1 | – | – | 1 |
| | Sierra Leone | – | – | 4 | – | 1 | 5 |
| | Somalia | – | 1 | 5 | 2 | – | 8 |
| | South Africa | – | 1 | – | – | – | 1 |
| | The Congo | 5 | 6 | 1 | 6 | 3 | 21 |
| | Togo | – | – | 1 | 1 | 3 | 5 |
| REST OF | Oman | – | – | – | – | – | 0 |
| WORLD | Papua New Guinea | 1 | – | – | – | – | 1 |
| | Yemen | – | 1 | 3 | – | – | 4 |
| Total at year end | | 246 | 191 | 180 | 201 | 162 | 980 |

Source: International Chamber of Commerce (ICC) International Maritime Bureau 2019
https://www.icc-ccs.org/icc/imb
* All incidents with above are attributed to Somali pirates

**Table 2**
Comparison of the type of attacks (2015~2019).

| Type | 2015 | 2016 | 2017 | 2018 | 2019 | Sub-total |
|---|---|---|---|---|---|---|
| Attempted | 27 | 22 | 22 | 34 | 17 | 122 |
| Boarded | 203 | 150 | 136 | 143 | 130 | 762 |
| Fired upon | – | 12 | 16 | 18 | 11 | 57 |
| Hijack | 15 | 7 | 6 | 6 | 4 | 38 |
| Total | 246 | 191 | 180 | 201 | 162 | 980 |

Source: International Chamber of Commerce (ICC) International
Maritime Bureau 2019. https://www.icc-ccs.org/icc/imb

**Table 3**
Types of violence to crew (2015~2019).

| Type | 2015 | 2016 | 2017 | 2018 | 2019 | Sub-total |
|---|---|---|---|---|---|---|
| Assaulted | 14 | 5 | 6 | – | 3 | 28 |
| Hostage | 271 | 151 | 91 | 141 | 59 | 713 |
| Injured | 14 | 8 | 6 | 8 | 7 | 43 |
| Kidnap | 19 | 62 | 75 | 83 | 134 | 373 |
| Killed | 1 | – | 3 | – | 1 | 5 |
| Missing | – | – | – | – | – | – |
| Threats | 14 | 10 | 10 | 9 | 6 | 49 |
| Total at year end | 333 | 236 | 191 | 241 | 210 | 1,211 |

Source: International Chamber of Commerce (ICC) International Maritime Bureau 2019 https://www.icc-ccs.org/icc/imb

**Table 4**
Types of Vessel attacked (2015~2019).

| Type | 2015 | 2016 | 2017 | 2018 | 2019 | Sub-total |
|---|---|---|---|---|---|---|
| Accommodation Barge | – | 1 | – | – | – | 1 |
| Bulk Carrier | 86 | 52 | 38 | 59 | 46 | 281 |
| Cable Ship | 1 | – | – | – | – | 1 |
| Cement Carrier | – | – | 1 | – | – | 1 |
| Container | 30 | 10 | 23 | 18 | 14 | 95 |
| Dhow | – | – | 3 | – | – | 3 |
| Dredger | – | 1 | – | – | – | 1 |
| Drilling Rig | – | – | – | 1 | – | 1 |
| FPSO (Floating Production storage and offloading)/FSO (Floating Storage and Offloading) | 2 | – | – | – | – | 2 |
| General Cargo | 15 | 11 | 12 | 6 | 7 | 51 |
| Heavy Lift Vessel | – | 4 | – | 1 | – | 5 |
| Heavy Load Carrier | – | 1 | – | – | 1 | 2 |
| Hopper Dredger | 1 | – | – | – | – | 1 |
| Landing Craft | – | – | – | 1 | 1 | 2 |
| Livestock Carrier | – | – | – | – | 1 | 1 |
| Hopper Dredger | 1 | – | – | – | – | 1 |
| Maintenance Pontoon | – | – | – | – | 1 | 1 |
| Ore Carrier | 1 | 1 | – | 1 | – | 3 |
| Passenger Ship | 1 | – | – | – | 1 | 2 |
| Pipe Lay Barge | 1 | 4 | – | – | – | 5 |
| Pipe Layer Crane Vessel | 1 | – | – | – | – | 1 |
| Pleasure Craft | – | – | – | – | 1 | 1 |
| Refrigerated Cargo | 3 | 1 | 2 | 2 | 2 | 10 |
| Research Ship | – | 2 | 2 | – | 1 | 5 |
| RO-RO (Roll-on/Roll-off) | – | – | – | 2 | – | 2 |
| Supply Ship | 2 | 4 | 8 | 5 | 2 | 21 |
| Support Ship | – | 1 | 2 | 2 | 1 | 6 |
| Tanker Asphalt/Bitumen | – | 1 | 1 | 1 | – | 3 |
| Tanker Bunkering | 1 | – | 1 | – | – | 2 |
| Tanker Chemistry/Product | 62 | 564 | 42 | 50 | 45 | 763 |
| Tanker Crude Oil | 20 | 13 | 19 | 16 | 19 | 87 |
| Tanker LNG (Liquefied Natural gas) | – | 1 | 3 | 2 | 2 | 8 |
| Tanker LPG (Liquefied Petroleum Gas) | 4 | 10 | 11 | 6 | 6 | 37 |
| Trawler/Fishing | 2 | 1 | 1 | 12 | 4 | 20 |
| Tug/ Offshore Tug | 10 | 14 | 11 | 11 | 7 | 53 |
| Vehicle Carrier | 1 | 2 | – | 1 | 2 | 6 |
| Wood Chips Carrier | 2 | – | – | – | – | 2 |
| Yacht | 1 | – | – | – | 1 | 2 |
| Total at year end | 246 | 191 | 180 | 201 | 162 | 980 |

Source: International Chamber of Commerce (ICC) International Maritime Bureau 2019. https://www.icc-ccs.org/icc/imb

### 2.2.1. International conventions and policies

To date, many international conventions and policies have been developed and implemented in attempts to strengthen maritime safety and security, such as the International Safety Management Code (ISM), the International Convention for the Safety of Life at Sea (SOLAS), the Port State Control Code (PSC), the International Ship and Port Facilities Security Code (ISPS), and others (Mukherjee, 2007; Bateman, 2010; Hallwood and Miceli, 2013; Pristrom et al., 2013; Weihai, 2017). The IMO[8] and the International

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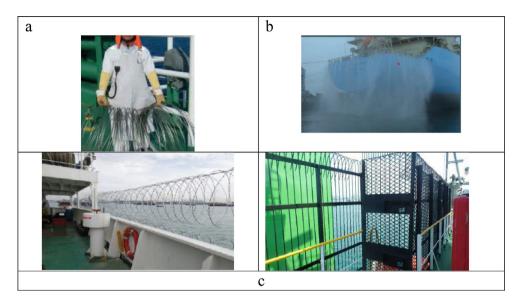[8] http://www.imo.org/en/Pages/Default.aspx

**Fig. 2.** (a) metal spike; (b) water spray; (c) protective metal mesh for the side and rear bridge windows.
Source: Witherby Publishing Group (2018)

Maritime Bureau[9] (IMB) regularly collect information on piracy and suggest effective defense polices for global shipping operators and related stakeholders (Kundsen and Hassler, 2011). For example, generally speaking, each international shipping company must develop its own ship security plan. The captain and all the crew are required to understand its operation procedure and contents. Also, in order to analyze dynamic pirate activities and develop effective defensive strategies, international maritime security organizations (e.g. the Security Center, Horn of Africa[10]) regularly collect piracy related information, and have developed anti-piracy guidance for industry and shipping companies. However, some research (Yang et al. 2013) suggests anti-piracy policy making should be more proactive. Practically, maritime security services can include private security companies who help organize armed personnel on board and naval (air) escorts (Weihai, 2017). Here, sub-criteria include ship security plan, piracy information collection and analysis, navy patrol protection participation, and armed guards on vessel.

### 2.2.2. Defense strategies in different high-risk areas

In order to defend against a variety of potential piracy attacks, it is argued that a captain's ship handling and management ability are key, since captains must effectively handle all emergency incidents and take appropriate decisions (e.g. ship speed, steering, etc.) (Weihai, 2017). Also, shipping companies usually evaluate high risk areas (e.g. the Gulf of Aden, Arabian Sea, Northern Indian Ocean and the Strait of Malacca) and arrange safe sailing routes and schedules for shipping services (Pristrom et al., 2013). Furthermore, for each shipping company, it is essential that the captain and all crew clearly understand security procedures and operate protective equipment and respond to piracy incidents. Here sub-criteria include the captain's ship handling and management ability, sailing planning and schedule, and the crew's response ability.

### 2.2.3. Ship's hardware and software

In order to identify or deter piracy threats, a ship must be equipped with hardware and software facilities, such as communication systems (e.g. automatic identification system, radar signal, etc.) and physical barriers for ship protection (Pristrom et al., 2013; Weihai, 2017; Witherby Publishing Group, 2018). Bateman (2011) shows that many seafarers serve in sub-standard vessels and are exposed to a higher risk of being hijacked by pirates. Therefore, strengthening a ship's construction and ensuring it has the necessary hardware and software are vital to both avoid and prevent pirate attacks. Here sub-criteria include communication facilities, physical barriers for ship protection, and ship alarm facilities. The above criteria and sub-criteria from the literature review are summarized in Table 5.

## 3. Methodology

This paper adopts a mixed analysis model by combining FAHP and in-depth expert interviews to explore effective defense strategies against piracy attacks. Data for the study was gathered from shipping companies, academics, government officials and shipping operators, based in Taiwan. All those working in shipping worked for international companies sailing in these waters, and Taiwanese

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9 https://www.icc-ccs.org/icc/imb
10 http://eunavfor.eu/the-maritime-security-centre-horn-of-africa/

**Table 5**

Summary of criteria and sub-criteria.

| Criteria | Sub-criteria | Description | References |
|---|---|---|---|
| International Convention and Policy | Ship security plan | Well organized ship security plan for shipping companies | Roe (2008); Bateman (2010); Fawcett (2010); Hallwood and Miceli (2013); Pristrom et al. (2013); Weihai (2017); Witherby Publishing Group (2018) |
| | Piracy information collection and analysis | Shipping companies and international organizations search and analyze piracy's activities and present effectively defence policies | |
| | Navy patrol protection participation | Navy conduct patrol service and avoid piracy attacks in high risk areas | |
| | Armed guards on vessel | Shipping companies hire armed guards on vessel and vessel safety protection services | |
| Defense strategies during various water areas | Captain's ship handling and management ability | Captain can use ship handling skills (e.g. ship speed, steering, etc.) and leadership management ability to avoid piracy attacks | Witherby Publishing Group (2018); Pristrom et al. (2013); Weihai (2017); Maritime Security Center, Horn of Africa. |
| | Sailing planning and schedule | Adequate sailing schedule design and time planning to guide ship access non-piracy attacks areas | |
| | Crew's response ability | Crew can effectively implement various ship protection plans and procedures (e.g. establishing a safe muster point or secure citadel) during high risk area (e.g. Suez and the Strait of Hormuz to the North, 10°S and 78°E.) | |
| Ship's hardware and software | Communication facilities | Using communication facilities (Radar, automatic identification system (AIS), VHF(Very high frequency)/SSB(Single-Sideband Emission), CCTV) to identify any specific threat and provide ship position report to maritime safety units (e.g. UK Maritime Trade Operations (UKMTO) in Dubai, The Maritime Security Centre – Horn of Africa (MSCHOA)) | Berking (2003); Weihai (2017); Maritime Security Center, Horn of Africa; Witherby Publishing Group (2018) |
| | Physical barriers for ship protection | Using physical facilities to increase the height and difficulty to prevent piracy's potential attacks and boarding (e.g. razor wire, the use of water/foam). Providing additional protection to bridge teams. | |
| | Ship alarm facilities | Using alarm facilities (e.g. lighting, dummy, whistle) to deter piracy attacks | |

http://www.mschoa.org/

**Table 6**
Characteristics of respondents.

| Type | Number | % | Type | Number | % |
|---|---|---|---|---|---|
| | Gender | | | Gender | |
| Male | 14 | 100.0 | Male | 7 | 100.0 |
| Female | 0 | 0 | Female | 0 | 0 |
| Total | 14 | 100.0 | Total | 7 | 100.0 |
| | Age(years) | | | Age(years) | |
| Less than 30 | 0 | 0 | Less than 30 | 0 | 0 |
| 31~40 | 0 | 0 | 31~40 | 0 | 0 |
| 41~50 | 10 | 71.4 | 41~50 | 1 | 14.3 |
| 51~60 | 4 | 28.6 | 51~60 | 6 | 85.7 |
| above 61 | 0 | 0 | above 61 | 0 | 0 |
| Total | 14 | 100 | Total | 7 | 100 |
| | Job title | | | Job title | |
| Section Director | 2 | 14.3 | Professor | 3 | 42.9 |
| Captain | 12 | 85.7 | Associate Professor | 4 | 57.1 |
| Total | 14 | 100.0 | Total | 7 | 100.0 |
| Company Type | Education Level | | | | |
| Container Ship | 7 | 50.0 | Ph. D. | 7 | 100.0 |
| Bulk Ship | 7 | 50.0 | Master | 0 | 0.0 |
| Total | 14 | 100.0 | Total | 7 | 100.0 |
| Less than 5 | 0 | 0.0 | Less than 5 | 0 | 0.0 |
| 6 ~10 | 0 | 0.0 | 6 ~10 | 1 | 14.3 |
| 11~15 | 6 | 42.9 | 11~15 | 4 | 57.1 |
| 16-20 | 7 | 50.0 | 16~20 | 2 | 28.6 |
| 21-25 | 1 | 7.1 | 21-25 | 0 | 0.0 |
| Total | 14 | 100.0 | Total | 7 | 100.0 |

It was purely coincidental, and not intentional, that participants were male.

shipping has suffered attacks from pirates. The theoretical content of FAHP and steps of the analysis of the expert interviews are detailed as follows:

### 3.1. Fuzzy Analytic Hierarchy Process (FAHP)

In this section, we first detail the methodology for the FAHP and then secondly for the interviews. Following this, the design and pre-testing of the expert questionnaire before its being administered to key participants is detailed.

The key participant categories we identified were: shipping operators (n=14) and academics (n=7) for the questionnaire; and government officials (n=3) and shipping operators (n=3) for the interviews. Regarding questionnaire participants, key participants' backgrounds (e.g. 10 year related working experiences at least or thorough knowledge of the research topic) were reviewed before inviting them to participate in the study in order to ensure they were experts. After obtaining their agreements of participation through phone calls or emails, a formal invitation letter was sent to these experts. The next stage was to administer the questionnaire to the key participants and, following the collection of effective questionnaires, to analyze these effective questionnaires to prioritize the criteria and sub-criteria. This prioritization reveals the key criteria for any discussion and conclusions to be drawn for stakeholders. The FAHP is a highly effective technique for analyzing Multi-Criteria Decision Making (MCDM) problems and has been widely used in many fields, such as shipping (Tseng and Cullinane, 2018), logistics (Fu et al., 2015), management science (Ahmed et al., 2016), and others. Using this technique, fuzzy linguistic variables and associated fuzzy triangular numbers can be used to make comparisons between the influential attributes and consequently provide effective solutions to vague and uncertain problems in decision making (Zadeh, 1965; Saaty and Vargas, 2012). Therefore, FAHP was selected as the most appropriate technique to analyze the piracy defense criteria decisions contained herein. Ultimately, this method can be justified because we combine fuzzy theory with the AHP method (Saaty, 1980). When combined, the FAHP avoids the overly crisp decisions associated with the AHP method alone, as these decisions inevitably produce imprecise results when applied to ambiguous problems (Chang, 1996; Kabir and Husain, 2011). Further, and as noted above, using FAHP combined with AHP offers a more effective dealing method to solve an unbalanced scale of judgement and can reduce any subjective judgments and preferences of decision makers (Kabir and Husain, 2011).

### 3.2. FAHP model construction

Based on Saaty (1980) and Chang (1996), the AHP stepwise algorithm used in this paper is shown as follows:

Step 1: Constructing an AHP model

Drawing on the previous literature review (see Table 6), an AHP model with three criteria and 10 sub-criteria is developed, assuming criteria and sub-criteria are independent.

Step 2: Evaluating the weights of different hierarchies

The main steps are described as follows:

A reciprocal value is assigned to the inverse comparison.

$$a_{ij} = \frac{1}{a_{ji}}$$ (1)

where $a_{ij}$ denotes the importance of the $i^{th}$ ($j^{th}$) element.

Pairwise comparison in AHP is made in the framework of a matrix, and a local priority vector can be derived as an estimate of relative importance associated with the elements (or components) being compared by solving the following equation:

$$A \times w = \lambda_{max} \times w$$ (2)

where A is the matrix of the pairwise comparison, w is the eigenvector, and $\lambda_{max}$ is the largest eigenvalue of A (Satty, 1980). Therefore, A is consistent if, and only if,

$$\lambda_{max} = n.$$

The consistency index (CI) of a matrix is given by

$$CI = \frac{\lambda_{max} = n}{n-1}$$ (3)

The consistency ratio (CR) is obtained by comparing the CI with the random inconsistency (RI) values, each of which is an average random consistency index computed for very large samples. The judgments in the comparison matrix are said to be consistent and therefore the relative priority vector estimation is accepted if the CR value is less than 0.1. The CR value is calculated as follows:

$$CR = \frac{CI}{RI}$$ (4)

Step 3 Calculating fuzzy numbers

Zadeh (1965) presents a fuzzy set as a class of objects with a continuum of grades of membership ranging between zero and one. A Triangular Fuzzy Number (TFN) is defined as three points and denoted as (l, m, u). The parameters l, m, and u represent the smallest possible value, the most promising value and the largest possible value, respectively, as shown in equation (5):

$$UA(x) = \begin{cases} \frac{x-1}{m-1}, & l < x < m \\ 1, & x = m \\ \frac{u-x}{x-m}, & m < x < u \\ 0, & 1 \geq x \geq u \end{cases}$$ (5)

Step 4: The fuzzy positive reciprocal matrix

Suppose $\tilde{A}$ is a fuzzy positive reciprocal matrix and can be expressed in the form:

$$\tilde{A} = [\tilde{a}_{ij}]$$ (6)

where the $n$ elements of this matrix, $\tilde{a}_{ij}$, represent the pairwise comparison between criterion $i$ and $j$ using fuzzy numbers, and is shown as follows:

$$\tilde{a}_{ij} = 1, \qquad \forall\, i = j$$ (7)

$$\tilde{a}_{ij} = 1/\tilde{a}_{ij}, \qquad \forall\, i \neq j$$ (8)

$$i, j = 1,\, 2\ldots..n$$ (9)

Step 5: Calculating the fuzzy weights

According to Buckley (1985), the fuzzy weights of each criterion in the fuzzy positive reciprocal comparison matrix are obtained by utilizing the geometric mean method. The geometric mean of the fuzzy comparison value of criterion $i$ to each other criterion is expressed as follows:

$$Z_i = (a_{i1} \times a_{i2} \times \ldots.a_{in})^{1/n}$$
$$\forall\, i = 1,\, 2,\ldots.n$$ (10)

The fuzzy weight of the $i^{th}$ criterion is represented by a triangular fuzzy number, and is computed as follows:

$$W_i = Z_i \times (Z_1 \times Z_2 \times \ldots.Z_n)^{-1}$$
$$\forall\, i = 1,\, 2,\ldots.n$$ (11)

Step 6: Defuzzification

Defuzzification can locate the best non-fuzzy performance (BNP) value based on the centre of the area, or centroid (Van Leekwijck and Kerre, 1999; Tseng and Cullinane, 2018). This step can conduct the transformational process from fuzzy triangular values into non-fuzzy values.

Step 7: Normalisation and synthetic analysis

In order to compare the relative importance attached to each of the evaluation criteria and sub-criteria, normalization and synthetic analysis are carried out. First, normalization is used to construct an overall priority rating. Then, a synthetic analysis is undertaken using this priority rating. The global weights are synthesized from the second level down by multiplying the local weights by the corresponding criterion in the level above, and adding them for each element in a level according to the criteria affected.

*3.3. Questionnaire measurement and respondents*

To validate the measures of the questionnaire content, during 1-10 April, 2018, 10 field experts were invited to a pilot study in order to refine the questionnaire, through measures such as improving its wording and readability. Then, before sending the refined and revised questionnaire, the backgrounds (e.g. working experience and professional ability) of potential respondents were reviewed and they were contacted to ensure they could participate in the study. A total of 22 questionnaires were administered by mail with postage-paid return envelope to 22 respondents (including 15 shipping operators and 7 academies)[11] on 21 April, 2018. By the cut-off date (5 May, 2018), 22 questionnaires had been received. For each sample, the consistency index (CI) and consistency ratio (CR) were individually tested to confirm the consistency of its pairwise comparison matrix. The results indicated that one questionnaire, with CI>0.1 and CR>0.1, was highly inconsistent (Saaty, 1980) and this questionnaire was consequently discarded. Therefore, the overall response rate was 95.5% (=21/22). The profiles of the 21 respondents' characteristics (including 14 shipping operators and 7 academics) are shown in Table 6. It can be seen that most respondents were senior experts and the majority had a minimum of 11 years working experience in shipping, thus strengthening the reliability of the research findings.

*3.4. Interviews*

The interviews were undertaken in May 2020 with government officials (n=3) with an average of 20 years' experience (ranging from 18 to 22) and with shipping operators (n=3) with an average of 23 years' experience (ranging from 22 to 25)[12]. In terms of the officials and operators interviewed in this qualitative stage, their ranks or positions were senior, being Section Manager, Vice Director and Director for the officials, and Manager, Vice Director and Manager and Container Ship Captain for the Shipping operators. Interview questions focused on interviewees' thoughts in relation to three main themes: 1. The impact of Piracy in general (and on their own companies with respect to the operators); 2. Strategies of defense that could be adopted and 3. Any further suggestions or comments they had for ships to defend themselves. Whilst there would have been particular advantages to exploring the specific FAHP results with interviewees, this approach was not adopted as it was considered more beneficial to conduct these interviews completely free of any informed criteria in order not to bias their direction. Also, we also asked for true piracy cases if they would like to share these stories, and any related response mechanisms to solve these problems. Interviews were undertaken in the interviewees' native language for ease of expression (cf[13]. Cortazzi et al., 2011), transcribed by the researchers to start the process of analysis (cf. Bird, 2005) and for reasons of anonymity (cf. Christians, 2011), and then analysed thematically (cf. Braun and Clarke, 2006) for what they revealed about the three identified themes and whether any other themes, or key messages, emerged.

## 4. Results and Analysis

Here we first present the FAHP Analysis results, and then those of the interviews. The analysis results of the FAHP are shown in Table 7. All the consistency ratio (CR) values are less than 0.1 and meet the consistency test. The results indicate that international convention and policy (0.475) is the most important criteria, followed by defense strategies when sailing in particular water areas (0.320), and ship's hardware and software (0.205). With regard to attributes, ship security plan (0.309), crew's response ability (0.377), and communication facilities (0.379) were perceived to be the most important sub-criteria. This was with respect to each of the international conventions and policies, defense strategies when sailing in particular water areas, and ship's hardware and software, respectively. Regarding the global weight, the results reveal that the three highest most important sub-criteria were ship's security plan (0.147), crew's response ability (0.121), and piracy information collection and analysis (0.117), respectively.

In terms of the interview data, the areas interviewees were asked about were their thoughts in relation to the themes of: 1. the impact of piracy; 2. the strategies that could be adopted to avoid attacks, and 3. whether they had any other comments or

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[11] Regarding the category of respondents, shipping operators (15) and academics (7) were chosen in this study for two reasons. First, shipping operators who have faced practical piracy attacks experiences could provide appropriate information for decision analysis in this study. Second, academics who have research experience and have a thorough knowledge about piracy attacks can offer another type of expert opinions. Such a combination (shipping operators and academics) could reduce potential analysis bias when adopting certain field experts' opinions. In terms of sample size, there is no standard regarding what number of experts is sufficient (Saaty, 1980). Nevertheless, a number of experts between 10~30 is acceptable and common in AHP or FAHP studies (e.g. Tseng and Cullinane, 2018). The number of academics who understand piracy attacks is limited (compared to shipping operators) in Taiwan. Therefore, the number of shipping operators (15) is about two times the number of academics (7) in this study.

[12] The interviews took place approximately two years after the administration of the questionnaire simply because of the challenge to arrange suitable times for them to take place given individuals' busy schedules.

[13] cf. is used to denote the Latin 'confer/conferatur' meaning to compare – i.e. where the information and approach we take compares to the source cited but is not directly the same as what was undertaken in that source.

**Table 7**
FAHP analysis results.

| Criteria | Weight | Sub-criteria | Local weight | Global weight | Rank |
|---|---|---|---|---|---|
| International convention and policy | 0.475 | Ship Security Plan | 0.309 | 0.147 | 1 |
| | | Piracy information collection and analysis | 0.245 | 0.117 | 3 |
| | | Navy patrol protection participation | 0.242 | 0.115 | 4 |
| | | Armed guards on vessel | 0.203 | 0.097 | 6 |
| Defence strategies during various water areas | 0.320 | Captain's maneuvering and management ability | 0.325 | 0.104 | 5 |
| | | Sailing planning and schedule | 0.297 | 0.095 | 7 |
| | | Crew's response ability | 0.377 | 0.121 | 2 |
| Ship's hardware and software | 0.205 | Communication facilities | 0.379 | 0.078 | 8 |
| | | Physical barriers for ship protection | 0.298 | 0.061 | 10 |
| | | Ship alarm facilities | 0.323 | | 9 |

suggestions[14]. The key message that consistently emerged throughout all the questions and from all the interviewees was that of the need for any approaches to defense against attacks to be implemented by shipping companies themselves, even if this sometimes meant working with government to do this.

With regard to the first theme, the impact of piracy was considered by all to be significant. For government officials, this may *"depend on what kind of pirate attacking"* occurred but some kinds were extremely severe, for, *"hijack, kidnap or killing, the loss will be huge."* The impact of piracy would be highly negative on *"mental pressure, working performance and feelings."* For another official, the economic impact could be severe, and *"it will affect the international business and commercial development."* One official alluded to the issue that the data may be incomplete, saying that *"many pirate issues are not announced in the world, some negotiations have happened under the table."* Thus, for officials, the impact was severe on crews, on the economy, and international business, and it could be that the true extent was not known if some attacks went unrecorded. Similarly, shipping operators also talked of *"significant impacts."*

In terms of theme 2, the strategies that could be adopted to avoid piracy, a key message that emerged was that approaches needed to be made by the companies. Even if, as one government official commented, the government, *"usually check… the ship can conduct effective defense strategies"* and the government *"regularly collect[s] and understand[s]… [the]… latest information and forward[s] to shipping companies,"* it is *"the shipping companies"* who *"will prepare the ship security plan to prevent potential loss and reduce operation risk."* For another official, specialist personnel could be hired, but here again it is the shipping companies who employ them: *"shipping companies can use private contracted armed security personnel to protect their crews and cargoes."* Operators also felt companies needed to adopt strategies to avoid piracy. For example, one operator noting that *"the shipping companies must prepare the security plan in each ship"* and another that *"the shipping companies will regularly do exercise and ask each crew… [to]… make sure everything is OK and safe."* In terms of the actual strategies that could be implemented, although as noted above, interviewees were not asked about strategies pinpointed in the FAHP in order to avoid any bias, similar criteria arose, such as hiring armed policemen, having a 'safe cabin' or adding protection facilities such as *"a grill window, broken glass on the deck, a high pressure spout."*

In relation to theme 3 of whether they had any other suggestions, once again the key message emerged that the shipping companies themselves should assume responsibility; although larger political institutions were also considered important. Government officials emphasised the importance of *"cross-international collaboration"* or to use *"case studies to develop response strategies,"* but that again it was *"the shipping companies"* who *"must effectively conduct safe education training for crews."* Here though, government officials did comment that government and shipping companies, could work together. For example that *"the government and shipping companies can regularly discuss effective mechanisms to avoid pirates attacking"*. One official felt this could be done through following the latest developments, for example that *"I suggest government units and maritime units should regularly understand… international trends and effectively respond to these uncertain pirate attacking issues."* Shipping operators had tactical suggestions specific for shipping companies to follow, such as that crews should not fight with pirates if they boarded, rather that *"the crew should wait for assistance from the shipping company or other units"*. Nevertheless, operators, similarly to government officials, also suggested companies and government should work together. This was also through remaining abreast of the latest information, for example suggesting that *"the government and shipping companies also continuously collect the latest pirate information and announce it"* and, similarly, that *"I think the shipping companies and the government should continuously collect the information on pirates."*

Thus, throughout all three themes focused upon in the interviews, the key message of the need for shipping companies themselves to assume responsibility was clear in the accounts of both officials and operators. For example, one government official commented that *"shipping companies must pay extra resource and time to avoid the pirate attacking"* and one operator noted that *"shipping companies… must invest money to protect themselves."* This was considered necessary in addition to international conventions, one operator observing that *"although there are some international conventions that can be used for regulating pirate behaviour, for shipping companies, they must invest money to protect themselves."* Further, although operators commented that companies *"will add insurance"* to reduce the risk of piracy, another underlined the importance of ensuring the documentation for the insurance specifically covered them, saying that *"it might be a problem that shipping companies… are not sure if they can get some compensation money back from the pirate insurances… [and]…*

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[14] It would have been relatively straightforward for us to associate the comments we draw upon here with specific officials and operators but we do not do this here. Primarily this is for reasons of anonymity, but we also consider it would add little value given that the seniority of rankings and lengths of experience of those interviewed were broadly similar.

*must review the insurance document (contract) to check the related laws and rules."* Even with insurance therefore, the key message was still that the responsibility was for the companies themselves to do the checking.

## 5. Discussion

Maritime piracy is an extremely important international safety and security issue, both for its quantitative occurrences (Tables 1, 2, 3 and 4) and the potential qualitative severity of these. During 2015~2019, major piracy attack areas were Indonesia and Nigeria (Table 1). The major type of piracy attacks were in the form of boarding, followed by attempted boarding, hijack and attempted hijack (Table 2). Taking the crew hostage was the most common strategy used by pirates, followed by kidnapping, threats and injuries (Table 3). The most commonly attacked ships were tanker chemistry/product and bulk carriers (Table 4) rather than other ship types. Arguably this is due to their slower speeds and lower freeboard levels when laden (Bateman, 2011). Piracy can be extremely traumatic for crew, and attack success is often facilitated by companies' use (whether through necessity or not) of sub-standard shipping (Bateman, 2011).

Regarding the results of the FAHP, international convention and policy criteria is strongly emphasized, followed by defense strategies and ship's hardware and software criteria. This will require well regulated rules and their implementation for maritime industries. These involve such procedures and documentation such as crews certificates, safety education training, Port State Control, etc. (Witherby Publishing Group, 2018). Each shipping company should actively follow these conventions and disclose the necessary information for port/ship officials through self-management. Relatively, defense strategies and ship's hardware and software belong to passive strategies against piracy attacks. However, these criteria can not be ignored even if their ranking is low.

Critically, as the qualitative interviews show, the key message that emerges from the perspectives of both officials and operators is that shipping companies themselves must take ownership of these initiatives. Regarding the potential impact of piracy, any strategies for ships to defend themselves and any suggestions for dealing with piracy, the key message is that it is the ships themselves that must be proactive to counter piracy. Concomitantly, the FAHP analysis above suggests ways in which they should prioritise how they go about this.

Given the vast area that is considered high-risk for piracy, and the nature of shipping company schedules meaning ships would not be travelling in convoy (Fawcett, 2010), it is not possible for continual naval or military escorts to be provided. Indeed, even when reporting to MSCHOA a vessel's entry into the high risk area, and even when giving daily reports on a ship's progress to UKMTO, if ships are attacked, it may not be possible for help to be sent (Witherby Publishing Group, 2018, p 21). Further, given the increase in piracy in times of economic crisis, the ability for state aid to improve social conditions in such countries from where piracy originates is highly unlikely (Baniela and Ros, 2012). Ultimately, at present, it is therefore left to ships themselves to do what they can to protect themselves, and both the operators and officials interviewed here agreed this should be the case. Yet, shipping companies may be unsure what others consider to be the optimum or primary approaches to prioritize to strengthen their defense. It is this aspect that this paper has focused on, in order to target and reveal key defense criteria and strategies for ships and shipping companies to implement themselves, although we also consider the findings of interest to policy makers as well.

## 6. Conclusion

This paper targeted the identification of strategies and approaches to piracy defense specifically for shipping companies and ships themselves to prioritize and adopt through an FAHP analysis and in-depth interviews. This approach complements the existing literature by outlining key priorities for ships themselves to focus on themselves. This is because the governments can help, and international guidelines and even potentially the navy can help ships, but ultimately it is the ships themselves that come under attack, and the paper identified priorities for them to focus on in their defense approaches and strategies. Regarding quantitative data, based on 21 expert questionnaires (including 14 shipping operators and 7 academies), findings indicated that the most important criteria is international convention and policy, followed by defense strategies when sailing in particular water areas, and ship's hardware and software. The top three sub-criteria are ship security plan, crew's response ability, and communication facilities. Regarding qualitative data, the three themes focused on were firstly of the impact of piracy, secondly of strategies to adopt to defend against piracy, and thirdly of suggestions for dealing with piracy. The key message that emerged from within all these themes was that the responsibility for any defense rests on the shipping companies themselves; from planning, to crew certification, to tactical measures to defend against piracy. Governments and international guidelines were considered key, but the shipping companies themselves need to defend their ships against piracy.

The results here suggest that priority be given to security plans and to training of crew in response and retaliation (cf. Weihai, 2017) as well as to overall policies on information gathering and response. In this context, although Navy patrol protection and participation may be unfeasible given the distances and areas involved (cf. Fawcett, 2010), enlisting the Navy to help in training crews could be an effective solution. When facing piracy attacks, shipping companies could help ensure captains are trained to effectively manoeuvre to avoid pirates approaching, and conduct leadership management ability (e.g. announcing emerging call for help (e.g. UKMTO), and arrange for crews to be safely confined in cabins or citadels quickly, to use deterrent measures such as metal spikes, water spray, protective metal mesh, etc.).

We note here, however, that although these issues were ranked as being the top three and thus are arguably ones that were accorded the highest priority, this does not mean that other factors such as alarm facilities and physical barriers should be ignored by companies. Rather, they should all be given attention, but that the first three are the ones arguably that should be given the most

attention. Notably, as the interview data underlined, shipping companies themselves should assume the onus and responsibility for strengthening any defenses and implementing security.

Notably, whilst the research outlined here was focused towards identifying what ships (and their companies) can do in the face of piracy, it also has potential implications for policy makers. We argue that the above results can help underpin arguments to policy makers and governments to either encourage or to legislate for greater training and planning to avoid piracy attacks, particularly given the importance accorded to government help with information by the interviewees.

Regarding future research, other MCDM methods could be used to extend related topics. For example, Analysis Network Process/DEMATEL could be used to investigate operation costs or risk evaluation regarding hostage, ransom and insurance issues. Also, extending the scope of interviews to include crews who have experienced either piracy attacks or attempted piracy attacks could explore strategic emergency response issues in real practical contexts. Further, if companies draw up specific plans based on the above and implement them, then their efficacy could be assessed and refined. In addition, to undertake research into piracy from Indonesia and Nigeria would help complement the existing body of research focusing on Somalia. We also add finally that, although it was coincidental that our research involved male participants, to undertake research also with female participants would provide a more equal picture of responses and complement existing perspective.

## Declaration of Competing Interest

None

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## References

Abila, S.S., Tang, L., 2014. Trauma, post-trauma, and support in the shipping industry: The experience of Filipino seafarers after pirate attacks. Mar. Policy 45, 132–136.

Ahmed, S., Ahmed, S., Shumon, M.R.H., Falatoonitoosi, E., Quader, M.A, 2016. A comparative decision-making model for sustainable and-of-life vehicle management alternative selection using AHP and extent analysis method on fuzzy AHP. Int. J. Sustainable Dev. 23 (1), 83–97.

Africa News. 2018. Resurgence of Piracy off the coast of Africa. Available at: http://www.africanews.com/2018/05/28/resurgence-of-piracy-off-somalia-s-coast/Last Accessed June 2018

Axbard, S., 2016. Income opportunities and sea piracy in Indonesia: Evidence from satellite data. American Economic Journal: Applied Economics 8 (2), 154–194.

Baniela, S.I., Ríos, J.V., 2012. Piracy in Somalia: A challenge to the International Community. The Journal of Navigation 65, 693–710.

Bateman, S., 2010. Maritime piracy in the Indo-Pacific region- ship vulnerability issues. Maritime Policy and Management 37 (7), 737–751.

Bateman, S., 2011. Sub-standard shipping and the human costs of piracy. Australian Journal of Maritime and Ocean Affairs 3 (2), 57–61.

Berking, B., 2003. Potential and benefits of AIS to ships and maritime administrations. WMU Journal of Maritime Affairs 2 (1), 61–78.

Bird, C.M., 2005. How I stopped dreading and learned to love transcription. Qualitative Inquiry 11 (2), 226–248.

Boot, M., 2009. Pirates, then and now: how piracy was defeated in the past and can be again. Foreign Affairs 88 (4), 94–107.

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qualitative Research in Psychology 3 (2), 77–101.

Buckley, J.J., 1985. Fuzzy hierarchical analysis. Fuzzy Sets Syst. 17, 233–247.

Chang, D.Y., 1996. Applications of the extent analysis method on fuzzy AHP. European Journal Operational Research 95, 649–655.

N.K. Christians, C.G., 2011. Ethics and politics in qualitative research. In: Denzin, N.K., Lincoln, Y.S. (Eds.), The Sage Handbook of Qualitative Research. Sage, Thousand Oaks, CA, pp. 61–80.

Cortazzi, M., Pilcher, N., Jin, L., 2011. Language choices and 'blind shadows': investigating interviews with Chinese participants. Qualitative Research 11 (5), 505–535.

Fawcett, J.A., 2010. Challenges to apprehension and prosecution of East African maritime pirates. Maritime Policy & Management 37 (7), 753–765.

Fu, X., Ng, A.K.Y., Lau, Y.Y, 2010. The impacts of maritime piracy on global economic development: the case of Somalia. Maritime Policy & Management 37 (7), 677–697.

Fu, H.P., Chang, T.H., Lin, A., Du, Z.J., Hsu, K.Y., 2015. Key factors for the adoption of RFID in the logistics industry in Taiwan. The international Journal of Logistics Management 26 (1), 61–81.

Gikonyo, C., 2018. Rationalising the use of the anti-money laundering regime in tackling Somalia's piracy for ransoms. International Journal of Law. Crime and Justice 52, 155–164.

Gauci, G., 2012. Total losses and the peril of piracy in English law of marine insurance. WMU J Maritime Affairs 11, 115–128.

Hallwood, P., Miceli, T.J., 2013. An examination of some problems with international law governing maritime piracy. Maritime Policy & Management 40 (1), 65–79.

Hanninen, M., Kujala, P., 2014. Bayesian network modeling of Port State Control inspection findings and ship accident involvement. Expert Syst. Appl. 41, 1632–1646.

Hong, N., Ng, A.K.Y, 2010. The international legal instruments in addressing piracy and maritime terrorism: A critical review. Research in Transportation Economics 27, 51–60.

Kabir, G., Hasin, A.A., 2011. Comparative analysis of AHP and Fuzzy AHP for multicriteria inventory classification. International Journal of Fuzzy Logic System 1 (1), 1–16.

Kiourktsoglou, G., Coutroubis, A.D., 2012. Is Somali piracy a random phenomenon? WMU Journal of Maritime Affairs 11, 51–70.

Kraska, J., Wilson, B., 2008. Fighting pirates: The pen and the sword. World policy journal 25 (4), 41–52.

Kundsen, O.F., Hassler, B., 2011. IMO legislation and its implementation: accident risk, vessel deficiencies and national administrative practices. Mar. Policy 35, 201–207.

Lambrou, C., 2012. The implications of piracy on marine insurance: some considerations for the shipowner. WMU J Maritime Affairs 11, 129–141.

Mukherjee, P.K., 2007. The ISM Code and the ISPS Code: A critical legal analysis of two SOLAS regimes. WMU Journal of Maritime Affairs 6 (2), 147–166.

Phillips, Z., 2009. Insurers on board with piracy risks. Bus. Insur. 43 (31), 11.

Pristrom, S., Li, K.X., Yang, Z., Wang, J., 2013. A study of maritime security and piracy. Maritime Policy & Management 40 (7), 675–693.

Randic, M., Matika, D., Moznik, D., 2015. SWOT analysis of deficiencies on ship components identified by port State Control inspections with the aim to improve the safety of maritime navigation. Brodogradnja 66 (3), 61–73.

Roe, M.S., 2008. Safety, security, the environment and shipping: The problem of making effective policies. WMU Journal of Maritime Affairs 7 (1), 263–279.

Saaty, T.L., 1980. The Analytic Hierarchy Process. McGraw-Hill, New York.

Saaty, T.L., Vargas, L.G., 2012. Models, methods, concepts & applications of the analytic hierarchy process (Vol. 175). Springer Science & Business Media.

Sevillano, J.C., Rios Insua, D., Rios, J., 2012. Adversarial risk analysis: The Somali pirates case. Decision Analysis 9 (2), 86–95.

Struett, M.J., Nance, M.T., Armstrong, D., 2013. Navigating the maritime piracy regime complex. Global Governance 19 (1), 93–104.

Szpak, Z.L., Tapamo, J.R., 2011. Maritime surveillance: Tracking ships inside a dynamic background using a fast level-set. Expert Syst. Appl. 38 (6), 6669–6680. doi:10.1016/j.eswa.2010.11.068.

Tominaga, Y., 2018. Exploring the economic motivation of maritime piracy. Defence and Peace Economics 29 (4), 383–406.

Transparency International. 2019. *Country Data: Somalia. Corruption Perceptions Index 2019*. Available at https://www.transparency.org/en/countries/somalia Last Accessed June 2020

Tseng, P.H., Cullinane, K., 2018. Key criteria influencing the choice of Arctic shipping: a fuzzy analytic hierarchy process model. Maritime Policy & Management 45 (4), 422–438.

Van Leekwijck, W., Kerre, E., 1999. Defuzzification: Criteria and classification. Fuzzy Sets Syst. 108, 159–178.

Vanek, O., Jakob, M., Hrstka, O., Pechoucek, M., 2013. Agent-based model of maritime traffic in piracy-affected waters. Transportation Research Part C 36, 157–176.

Varol, A.E., Gunal, M.M., 2015. Simulating prevention operations at sea against maritime piracy. Journal of Operational Research Society 66, 2037–2049.

Wambua, P.M., 2012. The jurisdictional challenges to the prosecution of piracy cases in Kenya: mixed fortunes for a perfect model in the global war against piracy. WMU Journal of Maritime Affairs 11, 95–113.

Weihai, L., 2017. A security model and legal guarantee for Chinese maritime shipping: As exemplified in the response to piracy along the 21st century maritime silk road. Social Sciences in China 38 (1), 46–65.

White, B.L., Wydajewski, K.J., 2002. Commercial ship self defense against piracy and maritime terrorism. In: OCEANS'02 MTS/IEEE 2. IEEE, pp. 1164–1171. doi:10.1109/OCEANS.2002.1192131.

Witherby Publishing Group, 2011. *Best Management Practices for Protection against Somalia Based Piracy*. Scotland, UK.

Witherby Publishing Group, 2018. *Best Management Practices to Deter Piracy and Enhance Maritime Security in the Red Sea, Gulf of Aden, Indian Ocean and Arabian Sea,*. Scotland, UK.

Yang, Y.C., 2010. Impact of the container security initiative on Taiwan's shipping industry. Maritime Policy & Management 37 (7), 699–722.

Yang, Z.L., Wang, J., Li, K.X., 2013. Maritime safety analysis in retrospect. Maritime Policy and Management 40 (3), 261–277.

Zadeh, L.A., 1965. Fuzzy Sets. Information and Control 8 (3), 338–353.