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Situational crime prevention and worldwide piracy: a cross-continent analysis

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Abstract

Relying on situational crime prevention perspective, this study compares successful and unsuccessful pirate attacks reported to the International Maritime Bureau (IMB) from the year 2000 through 2013 (n = 4,902). The study builds upon the recent work of Shane and Magnuson in Justice Quarterly, pp 1–26 (2014), which found various SCP techniques effectively prevented piracy attacks on a global level. The current study builds upon these findings by testing whether the global effect of SCP is consistent across individual continents. A series of mixed-effects logistic regression models and follow-up likelihood ratio tests were incorporated to explore the research question. In each model, SCP techniques were associated with unsuccessful piracy attacks on a global level. When considered individually, SCP techniques were equally effective in each continent. However, the use of multiple techniques classified within the *increased effort* technique of SCP was associated with increased likelihood of unsuccessful attacks in only 3 (South East Asia, Far East, and Rest of the World) of the 6 continents included in this study. The implications of these findings are discussed.

Keywords: Piracy, Opportunity, Shipping industry, Situational crime prevention, Logistic regression, Vessel security

Background

Piracy reports from the International Maritime Bureau (IMB) reveal that actual and attempted attacks against ships worldwide have increased 129% between 1991 and 2014, with large spikes between 2000–2003 and 2009–2011 (IMB 2014a). Although some downward trends began in 2011, led primarily by reductions around the Straits of Malacca, piracy in Sub-Saharan Africa continued to escalate mostly off the coast of Somalia, Tanzania and around the Gulf of Aden (Prins 2014) with sustained rates of violence. The IMB recently reported that attacks against small tankers around the coast of Southeast Asia were responsible for a 75% increase in global ship hijackings between 2013 and 2014 (IMB 2014b).

Piracy continues to pose a threat to the world's economic interests particularly in the Horn of Africa region (Bowden 2010; Salopek 2013; US National Security Council 2014 p. 4) and is largely driven by macro-level land-based social disorganization (Fund For Peace 2014) that facilitates crime and corruption, which enables piracy (Ho 2009; Middleton 2008). United States foreign policy in this region is based largely on a strategy of limited coalition and multinational agreements that address piracy; a permanent solution will require a sustained long-term international effort that includes diplomatic, economic, social, military, intelligence, law enforcement and judicial intervention (De Montclos 2012; Otto 2011; US National Security Council 2014; van Ginkel and Landman 2012).

The shipping industry cannot wait for these political and law enforcement measures to materialize to reduce piracy and improve safety. The international law enforcement community is not necessarily well suited to address piracy, particularly when dealing with states that are at risk of failure (Forsyth et al. 2009, p. 672; also see Murphy 2008, 2009). This is complicated by legal constraints (Chalk 2010; Gill 1996; Hawkins 2009; Kraska and Wilson 2011; Murphy 2011; Sterio 2011) and delays associated with defining and codifying piracy, wrangling diplomatic efforts, financing prosecutions, crafting international agreements and establishing legal jurisdiction (Fokas

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Shane *et al. Crime Sci* (2015) 4:21

Page 2 of 13

1997; Hong and Ng 2010). Although a long-term strategy is important to regional stability, the daily approach to address piracy requires a tactical effort that can be applied when vessels are threatened. The world's oceans are vast, remote, unassigned spaces (Felson 1994) that make piracy easier to perpetrate, harder to detect and prevent, but not inevitable. There are methods that merchant marines and their vessels can employ to protect themselves that alter the transit environment and their immediate situational perspective before an attack and while an attack is underway. The situational crime prevention (SCP) approach is informed by analysis that focuses on the crime, not the criminal. It values prevention over arrest and empowers the individual over the government to construct a safer environment when traditional law enforcement or military resources are not available (Clarke 1997; Goldstein 1979).

Most previous studies analyze piracy from a descriptive or macro-level perspective, which is too generalized to offer substantive crime prevention measures (e.g., Psarros et al. 2011; Wong and Tsz Leung 2012). SCP is a micro-level approach with a wide body of research touting its crime control benefits (e.g., Clarke 1997). An emerging body of research now extends SCP techniques to piracy with promising results (Bryant et al. 2014; Shane and Magnuson 2014). The present study aims to widen the SCP literature by testing whether the SCP techniques found in previous piracy studies are equally effective across different regions of the world.

Literature review

The current literature on piracy mainly lacks a criminological perspective (Twyman-Ghoshal 2014) and is largely focused on describing its frequency and nature in terms of trends and patterns such as those around the Singapore Strait and South China Sea (Von Hoesslin 2012), Nigeria (De Montclos 2012), Southeast Asia and Africa (Jeong 2015). Other studies examine the types of vessels most often attacked along with the weapons used (Sullivan 2010), as well as attacks that cluster in time and space (Talley and Rule 2008; Townsley and Oliverira 2012; Marchione and Johnson 2013).

Piracy varies by region in terms of frequency, violence, distance from the shore, time of day and the ship's position (Nincic 2009; Twyman-Ghoshal and Pierce 2014). Southeast Asia experienced the highest number of pirate attacks compared to other regions in the 1990's (Chalk 1998; Twyman-Ghoshal and Pierce 2014), particularly near the Singapore Straits, the Malacca Straits and Indonesia (Beckman 2002). By comparison, piracy around Africa remained constant between 2001 and 2006, then increased after 2006 (Twyman-Ghoshal and Pierce 2014) with Nigeria and Somalia experiencing the most attacks

(Nincic 2009). Von Hoesslin (2012) notes that while most pirate attacks in Southeast Asia occur close to shore, more are occurring further out at sea. This trend has yet to be observed off of the Indian subcontinent, where attacks primarily occur in local waters (Twyman-Ghoshal and Pierce 2014).

Pirate tactics, strategies and level of organization also vary by region (Nincic 2009; Davenport 2012). Although Nigerian pirates focus on oil tankers (Jeong 2015), Somali pirates prefer ransom through kidnapping and pirates in Southeast Asia focus on opportunistic theft when ships are at anchor or berth (Beckman 2002; Nincic 2009; Ploch et al. 2011; Davenport 2012). Pirates operating around the Indian subcontinent are motivated by theft (Twyman-Ghoshal and Pierce 2014) and attacks around Bangladesh and India were found to mostly occur on stationary vessels, while pirates in Indonesia attacked both moving and stationary ships equally (Twyman-Ghoshal and Pierce 2014).

Pirates are also more sophisticated and organized around Southeast Asia compared to East Africa because failed states (e.g., Somalia) hamper the pirates' ability to create complex networks (Hastings 2009). Pirates in Africa tend to be armed with more advanced weapons (e.g., guns, rocket-propelled grenades) compared to pirates in Southeast Asia who are usually armed with knives and crowbars (Nincic 2009; Sullivan 2010; Twyman-Ghoshal and Pierce 2014). Unlike African and Southeast Asian pirates, Indian pirates are rarely armed (Twyman-Ghoshal and Pierce 2014). Although African pirates are more likely to become violent compared to pirates in Southeast Asia (Nincic 2009; Von Hoesslin 2012), Sullivan (2010) and Ploch et al. (2011) note that most Somali pirates do not kill their victims since their goal is ransom.

Adding to the complexity of different types of piracy and pirate groups is the notion that piracy itself is an evolving phenomenon (Dua and Menkhaus 2012; Twyman-Ghoshal and Pierce 2014; Sörenson and Widen 2014). The changing nature of piracy can be seen in Von Hoesslin's (2012) research indicating that sophisticated and organized groups operating in the Singapore Strait and the South China Sea have adapted to anti-piracy measures implemented by government and law enforcement. This is yet another example of why shipmasters cannot rely on traditional government and law enforcement for protection.

From the offender's perspective, several studies suggest the primary motivation behind piracy is money (O'Meara 2007; Chalk 2009; Hansen 2012; Gjelsvik and Bjørgo 2012), with economic conditions being a main contributing factor (Vagg 1995; Clark 2009; Onuoha 2009; Von Hoesslin 2012). An important piece of the equation that

Shane *et al. Crime Sci* (2015) 4:21

Page 3 of 13

is missing from previous studies is opportunity, which is present in all crime (Felson and Clarke 1998) and is a contributing factor in piracy. Understanding how opportunity arises in the piracy context is most complete when examined through a situational crime prevention lens, which accounts for the victim, the offender *and* the environmental influences. The overwhelming majority of previous studies stop short of offering specific measures to prevent piracy and do not account for immediate situational perspective that influences the pirates' decision to attack.

Theoretical framework
Situational crime prevention
Situational crime prevention is particularly relevant to piracy, since it assists in identifying measures that are effective in disrupting the opportunity for an attack (Clarke 1980, 1997, 2013). SCP is informed by the three separate theories of environmental criminology, which, when taken together, amount to "opportunity theory:" routine activities (Cohen and Felson 1979; Felson and Cohen 1980), crime pattern (Brantingham and Brantingham 1975, 1984, 1993), and rational choice (Cornish and Clarke 1986). Fundamental to environmental criminology is the disruption of crime opportunities by manipulating or altering the environment. Opportunities arise when a suitable target (vessel), converges in time and space with a motivated offender (pirate) in the absence of a capable guardian (crew or other authority) (Cohen and Felson 1979). This represents the interaction between an offender and their environment, which is a departure from the traditional "dispositional" theories of crime and criminality (e.g., Cullen and Agnew 2006). An offender's disposition (i.e., motivation) is a constant in the crime equation, so understanding the characteristics of the target (those that make it more or less attractive) and the environment (those facilitate or inhibit the offender's actions) is where SCP begins to take shape.

Unique to SCP when compared to traditional criminological theories is its focus on proximate situational factors contributing to a crime, as well as its focus on specific forms of crime (Clarke 1995, 1997, 2013). There is a seemingly infinite supply of motivating factors some of which can be controlled by society, but which cannot necessarily be controlled as an attack begins. As such, SCP theory concentrates on controlling the immediate situational environment and preparing for an offender's overt attempt to seize control of the target. When viewed from this perspective it is easier to design crime prevention measures that focus on disrupting the convergence setting than it is to shape the range of social problems that affect someone's personal circumstance.

Manipulating physical and environmental temptations resides with "controllers:" (1) *capable guardians* who can alert authorities or physically intervene to stop the offender; (2) *intimate handlers* who personally know the offender or who know them by proxy and can exert control over their actions and (3) *managers* who have responsibility for controlling behavior and environmental conditions at specific places (Felson 1995). Cornish and Clarke (2003) developed a classification system of 25 situational techniques organized around five categories (increasing the effort, increasing the risks, reducing the rewards, reducing provocations, removing excuses) that controllers can employ to block opportunities for crime to occur. The core focus is to mobilize public, private and non-profit resources that are in a position to systematically alter the immediate environment, which makes a successful attack less likely (Clarke 1980, 1997).

Perpetrating a successful crime partly depends on the offender's calculus about the amount of effort and risk required, as well as the potential reward. Consequently, actions taken by prospective victims can influence the opportunity for crime by manipulating certain aspects of their immediate environment so the crime is harder to commit, or the eventual rewards are denied. There is strong empirical support for SCP across several forms of crime and delinquency (Clarke 1997). While early studies focused on traditional land-based crime (e.g. burglary, motor vehicle theft, alcohol violence, poaching and wildlife crimes), Shane and Magnuson (2014) recently applied the theoretical framework to piracy. In that study, the authors found that when a ship's crew takes proactive self-protective measures that increase the perceived effort and increase the perceived risk of perpetrating an attack, unsuccessful attacks are significantly more likely after controlling for environmental influences. The bivariate analyses revealed support for SCP theory, in that certain crime prevention techniques were significantly associated with unsuccessful attacks. In substantive terms this suggests that unsuccessful attacks tend to increase where each of the predictor variables are more pronounced. The authors extended the bivariate model further by creating a composite index for increasing perceived risk (raising alarm, anti-piracy watch, private security, watchman present, increasing lighting) and increasing perceived effort (electric perimeter fencing, evasive maneuvers, increasing ship speed) and found a significant positive relationship with a moderate effect size, where an increase in the composite scores was associated with an increase in unsuccessful attacks. The multivariate model also supported SCP theory; as the presence of SCP factors increased, so did the likelihood of an unsuccessful attack and the full model accounted for 41.5% of the variance in the outcome variable.

Shane *et al. Crime Sci* (2015) 4:21

Page 4 of 13

Situational crime prevention and piracy

Prior research suggests that three SCP techniques are particularly salient in preventing maritime piracy: *Increasing the Perceived Effort to Commit Piracy, Increasing the Perceived Risk to Commit Piracy*, and *Reducing the Anticipated Rewards of Piracy.* Increasing the perceived effort means controlling access to places where offenders do not belong by erecting real and symbolic barriers that signal a given area is restricted (Guerette and Clarke 2003; Landes 1978; Loomis et al. 2002; Sherman and Rogan 1995; Wallis and Ford 1980). Rengelink (2012) extended this to the piracy environment and found the most effective measures included increasing the ship's speed, engaging in evasive maneuvers and deploying a "sonic gun" (to deflect offenders) (see BBC 2007). Deflecting offenders disrupts the convergence setting and has also been shown to reduce gang homicides and assaults (Lasley 1998) and robberies (Poyner 1994). A separate study examined the layering effect of SCP measures and found that pirates did not board vessels when at least four SCP measures were employed (Twyman-Ghoshal and Pierce 2014).

Increasing the perceived risk means increasing the chance of being apprehended or identified, which means raising the prospect the pirates will be seen by someone who can take affirmative action (e.g. the crew, port employees, local authorities) to prevent the attack. Perceived risk involves a cost-benefit calculation by the offender based on the qualities of the target that make it more or less suitable for attack (Felson and Clarke 1998, p. 54–55). By deliberately augmenting employee surveillance (e.g. lighting, warning alarms), increasing guardianship (e.g. watchmen) and assigning specific on-board activities (e.g. antipiracy watch, shipboard security), a shipmaster can maximize visibility that leaves pirates sensing increased crew vigilance, which has been supported by previous research in other areas (Braga et al. 1999; Clifton 1993). Rengelink (2012) found that naval force intervention was an effective measure of increasing guardianship that reduced piracy. An alert crew (e.g., watchmen) was also found to be an effective deterrent to piracy (Forsyth et al. 2009); in fact, one study found that when keeping watch and enhanced vigilance were used together with at least two other protective measures, the chances of disrupting a pirate attack greatly increased (Bryant et al. 2014).

Reducing anticipated rewards means removing the target from contact with the offender. If the target is not available, then there is little temptation to continue pursuing the crime. In many instances it is the ship's crew and not the ship or the cargo that tempts the attack, since holding the crew hostage may yield substantial ransom. If the crew is mustered to a safe room,[a] then access is denied. This removes the object of the attack and may instigate pirates to retreat from their assault. Denying pirates the benefit of kidnapping or taking the crew hostage when they board is similar to removing a domestic violence victim to a safe house to avoid an attack (Storey et al. 2014), but this is speculative since evaluating safe rooms aboard ships has yet to be studied.

The present study

In this study we build upon Shane and Magnuson (2014) in two ways. First, we incorporate an additional year of data (2013) to further test the effect of SCP on attempted piracy attacks. Second, we examine whether SCP techniques hold across continents given the variety of piracy worldwide among developing countries. Given local factors, SCP techniques may not be equally effective around the globe, but may be more or less effective depending on contextual factors of the pirates, ship crews, and/or settings of the individual continent. We create a series of individual and aggregate analyses to test whether situational crime prevention techniques are equally effective in preventing attacks across continents.

Methodology

Data and descriptive statistics

Data were acquired from publically available reports of the IMB Piracy Reporting Centre (n = 4,902). Data from 2000 to 2009 were collected by Coggins (2012), while Shane and Magnuson (2014) and the authors collected the remainder. The IMB follows the definition of Piracy provided in Article 101 of the 1982 United Nations Convention on the Law of the Sea.[b] The unit of analysis is pirate attacks reported to the IMB Piracy Reporting Centre. Variables in the analysis were coded from questions published in the Live Piracy Report. Coding followed the schema developed by Shane and Magnuson (2014). The dependent variable is binary measuring whether the attack was unsuccessful (1) or successful (0). An unsuccessful attack refers to any piracy attempt resulting in "(1) approaching a ship but not boarding or (2) boarding a ship but leaving without any proceeds" while successful attacks refer to piracy attempts resulting in "(1) hijacking, (2) ransom, or (3) theft" (Shane and Magnuson 2014, p. 8). In total, nine predictor variables measure the use of SCP techniques by the ship's crew during the attack. Five predictor variables are classified according to the *increasing the perceived risk* category of SCP: the use of *anti-piracy watch*, the presence of *private security personnel, raising the alarm*, the presence of *watchmen*, and *increased lighting*. Four predictor variables are classified according to the *increasing the perceived effort* category of SCP: *electric perimeter fencing, evasive maneuvers, increasing speed*, and *mustering the crew* in a fortified safe room aboard the ship.[c] Each of these variables is

Shane *et al. Crime Sci* (2015) 4:21

Page 5 of 13

operationalized as a binary value, measuring its presence (1) or absence (0). To measure the totality of SCP techniques employed by the ship's crew, two continuous variables were created. The first, *Increase Risk Index*, is the sum of the five aforementioned *increase risk* variables. The second, *Increase Effort Index*, is the sum of the four aforementioned *increase effort* variables. In addition to the predictor variables, the analysis incorporates six control variables to account for factors that may exert influence over the outcome of an attack, specifically *time of day*, *quarter of the year*, the ship's *attack status* (stationary vs. steaming), *type of vessel*, *the number of pirates*, and *the presence of weapons* (i.e., armed pirates).

Table 1 displays descriptive statistics. About half of the attacks (n = 2,351; 49.4%) were unsuccessful. The *Increase Risk Index* shows that in nearly half of the incidents (n = 2,180; 47.9%) the ship's crew did not incorporate any SCP techniques meant to increase the perceived risk of piracy. When such techniques were used, they were most often raising the alarm (n = 1,917) and the presence of watchmen (n = 1,241). Increased lighting (n = 206), private security (n = 265), and anti-piracy watches (n = 307) were employed with much less frequently. During approximately 25% of incidents (n = 1,138) the crew used multiple *increase risk* techniques. Approximately 70% of incidents (n = 3,207) did not involve the use of any i*ncrease effort* tactics. The most commonly employed *increase effort* tactic was mustering the crew (n = 801) followed by evasive maneuvers (n = 667), increasing speed (n = 410) and electric perimeter fencing (n = 24). Multiple *increase effort* tactics were used in only 8.3% of incidents (n = 408). Examining the control variables, most attacks occurred between the hours of 00:00 and 05:59 (n = 1,964; 48.6%). Incidents were relatively evenly spread across the four quarters of the year; 26.4% of incidents (n = 1,294) involved armed pirates, and ships were attacked most often when stationary (n = 2,568; 53.2%) rather than steaming (n = 2,255; 46.8%). The number of pirates involved in an attack ranged from 1 to 200, with a mean of 6.37 and standard deviation of 7.13, suggesting wide variability across incidents. Tankers (29.4%) and bulk carriers (23.3%) were the most frequently targeted vessel types.

Table 2 displays the frequency of pirate attacks across continents. Attacks most frequently occurred in Africa (38.7%) and Southeast Asia (33.2%). Overall, attacks were nearly evenly split between successful (n = 2,404; 49.0%) and unsuccessful (n = 2,351; 48.0%). However, variability did exist across continents. Africa exhibited the highest proportion of unsuccessful attacks, with pirates failing to hijack the ship and/or obtain proceeds in 59.3% of incidents. The Far East exhibited the highest proportion of successful attacks, with pirates securing proceeds

Table 1 Descriptive statistics

Variables	n	%
Dependent variable: unsuccessful attack		
Yes (1)	2351	49.4
No (0)	2404	50.6
Independent variables		
Increase perceived risk variables		
Increased Risk Index		
0	2180	47.9
1	1237	27.2
2	1051	23.1
3	87	1.9
Alarm raised		
Yes (1)	1917	39.7
No (0)	2913	60.3
Watchman present		
Yes (1)	1241	25.7
No (0)	3589	74.3
Anti-piracy watch		
Yes (1)	307	6.4
No (0)	4520	93.6
Private security		
Yes (1)	265	5.5
No (0)	4565	94.5
Increased lighting		
Yes (1)	206	4.3
No (0)	4622	95.7
Increase perceived effort variables		
Increased Effort Index		
0	3207	70.4
1	939	20.6
2	345	7.6
3	62	1.4
4	1	0.0
Evasive maneuvers		
Yes (1)	667	13.8
No (0)	4161	86.2
Crew mustered		
Yes (1)	801	16.5
No (0)	4068	83.5
Vessel increase speed		
Yes (1)	410	8.5
No (0)	4414	91.5
Electric perimeter fence		
Yes (1)	24	0.5
No (0)	4844	99.5
Control variables	**n**	**%**
Time		
00:00–05:59	1964	48.6
06:00–11:59	680	16.8
12:00–17:59	533	13.2

Shane *et al. Crime Sci* (2015) 4:21

Page 6 of 13

Table 1 continued

Control variables	n	%
18:00–23:59	867	21.4
Quarter of the year		
1 Qtr.	1194	24.4
2 Qtr.	1364	27.8
3 Qtr.	1146	23.4
4 Qtr.	1198	24.4
Weapons present		
Yes (1)	1294	49.1
No (0)	1344	50.9
Vessel status		
Stationary (0)	2568	53.2
At sail (1)	2255	46.8
Number of pirates		
Mean	6.37	na
Standard deviation	7.13	na
Min.	1	na
Max.	200	na
Vessel type		
Tanker, bulk carrier, or container (1)	3401	69.4
Other vessel type (0)	1501	30.62
Year		
2000	469	9.6
2001	334	6.8
2002	370	7.6
2003	448	9.1
2004	335	6.8
2005	276	5.6
2006	239	4.9
2007	263	5.4
2008	295	6.0
2009	407	8.3
2010	458	9.3
2011	442	9.0
2012	301	6.1
2013	265	5.4

in 62.1% of incidents. A Pearson Chi square test found that the frequency of successful and unsuccessful attacks significantly varied across continents ($\chi^2 = 168.03$; *p.* < 0.01) with a small effect ($V = 0.19$, Cohen [1988]).[d] This demonstrates that both the frequency and outcome of piracy attacks differs across continents and points to the need to test whether the global effect of SCP detected by Shane and Magnuson ([2014]) is maintained within each individual continent.

Analytic approach

This study addresses the research question *Is the effect of SCP techniques on piracy attacks consistent across continents?* The research hypothesis (H_1) is that situational crime prevention techniques will be equally effective in preventing successful attacks across continents. To explore this question, we conducted a series of mixed-effects logistic regression models to predict unsuccessful pirate attacks. Mixed-effects models allow "analytical procedures to simultaneously incorporate individual and group-level causal processes" (Johnson [2010], p. 621). This is accomplished by modeling two different effects: individual level effects (level 1), with intercepts and slopes describing the population as a whole, and group level effects (level 2), with intercepts and slopes varying across subgroups (Hamilton [2013]; Johnson [2010]). In the current study, the individual level refers to the total population of pirate attacks reported to the IMB (level 1) and the group-level refers to the six continents represented in the dataset (level 2). While simpler modeling procedures are capable of accounting for clustering of cases within singular data sets (e.g. using robust standard errors adjusted to each group within a standard regression model) such approaches preclude examination of between-group differences (Johnson [2010], p. 628), which is the key aim of this paper. The random effects model allows for the possibility that the occurrence of unsuccessful attacks, and their significant predictors, differs across continents. Such an analytical approach seems appropriate given the patterns observed in Table [2]. Collinearity diagnostics showed no evidence of multicollinearity.[e]

First, a random-intercept model was run that allows intercepts to vary across continents. With the random intercepts accounted for in the calculation of the regression coefficients, the results report the population-wide effect of the predictor variables on the dependent variable (Hamilton [2013], p. 394). To explore the effect of the predictor variables across sub-sets of the population (e.g., continents) we conducted a series of random-intercept-and-slope models allowing the slopes associated with each given SCP predictor variable to vary across continents. A likelihood-ratio (LR) test then measured whether the fit of the random-intercept-and-slope model significantly improved upon that of the random-intercept model. A significant finding ($p < .05$) suggests that the predictor's effect on the likelihood of an unsuccessful attack differs significantly across continents. In such cases, the slope for each continent was graphed to allow for visual inspection of the heterogeneous effect of the technique. This process was repeated multiple times, once for each of the SCP variables in the model.

We conducted two distinct sets of analyses in exploration of the research question. The first, which we refer to as the "aggregate analysis," incorporates the *increased risk* and *increased effort* indices as predictor variables. This

Table 2　Piracy attacks across continents

Continent	Successful attacks (% of category)	Unsuccessful attacks (% of category)	Unknown attack status (% of category)	Total attacks (% of total)
Americas	271 (56.8)	191 (40.0)	15 (3.1)	477 (9.7)
Africa	720 (38.0)	1124 (59.3)	52 (2.7)	1896 (38.7)
South East Asia	901 (55.4)	681 (41.9)	45 (2.8)	1627 (33.2)
Far East	182 (62.1)	95 (32.4)	16 (5.5)	293 (6.0)
Indian sub-continent	295 (54.8)	233 (43.3)	10 (1.9)	538 (11.0)
Rest of the world	35 (52.2)	27 (40.3)	5 (7.5)	67 (1.4)
Not reported	0 (0)	0 (0)	4 (100.0)	4 (0.1)
Total	2404 (49.0)	2351 (48.0)	147 (3.0)	4902 (100.00)
Pearson χ^2	168.03			
p	<.01			
Cramer's *V*	0.19			

Sum of percentages does not equal exactly 100 % due to rounding. The Chi-square test was conducted on a 6 × 2 cross tabulation with continent of attack (Americas, Africa, South East Asia, Far East, Indian sub-continent, Rest of the word) as the rows and attack status (successful or unsuccessful) as the columns

measured the effect the cumulative use of SCP had on the occurrence of unsuccessful pirate attacks, and its variance across continents. The second, termed the "disaggregate analysis," incorporated seven individual SCP techniques as predictor variables: *alarm raised, watchman present, anti-piracy watch, private security, increased lighting, evasive maneuvers*, and *crew mustered*.[f] This extends the aggregate analysis by exploring the effect of specific SCP tactics, rather than SCP as a whole, and measuring their heterogeneity across continents. In both the aggregate and disaggregate models, the aforementioned control variables were included.

Results

Table 3 displays the results of the aggregate logistic regression models. Both the *Increased Risk Index* and the *Increased Effort Index* were statistically significant and associated with increased likelihood of an unsuccessful attack. For both *increased risk* (Exp[B] = 2.81) and *increased effort* (Exp[B] = 2.66) odds ratios suggest that for every additional tactic employed, the chance for an unsuccessful attack increased over two-fold. Of the control variables, both the *06:00–11:59* time period (Exp[B] = 2.21), and *attack status* (Exp[B] = 2.19) were significantly associated with an increased likelihood of an unsuccessful attack. The *presence of weapons* was associated with a significantly decreased likelihood of an unsuccessful attack (Exp[B] = 0.27).

Table 4 displays the results of the aggregate likelihood-ratio tests, which measures whether slopes of the SCP *index* variables significantly differed across continents. Results illustrate that, with respect to the *Increased Effort Index*, the fit of the random intercept-and-slope model was not superior to the random intercept model (*p* = .10). This suggests that the effect of the *Increased*

Effort Index was relatively stable across continents. Conversely, results suggest that the fit of the random intercept-and-slope model was significantly better than the intercept model in the case of the *Increased Risk Index* (*p* = .01). This suggests that the effect of the *Increased Risk Index* on unsuccessful attacks significantly varied across continents.

Figure 1 presents the heterogeneity of the *Increased Risk Index* and the odds ratios (Exp[B]) associated with each continent.[g] In total, the *Increased Risk Index* was associated with the increased likelihood of an unsuccessful attack on three continents: South East Asia, Far East, and Rest of the World. Of these three, the effect was largest in South East Asia, with each one-unit increase in the index associated with a 56% greater likelihood of an unsuccessful attack (Exp[B] = 1.56). Conversely, the *Increased Risk Index* was associated with a decreased likelihood of an unsuccessful attack in the Americas (Exp[B] = 0.69), Africa (Exp[B] = 0.70), and the Indian Sub-Continent (Exp[B] = 0.91).

Table 5 presents the results of the disaggregated logistic regression models. Four of the five SCP techniques were significantly related to the increased likelihood of an unsuccessful attack. Odds ratios ranged from 1.58 in the case of *crew mustered* to 27.02 in the case of *evasive maneuvers*. The only SCP technique that did not achieve statistical significance was *anti-piracy watch* (*p* = .14), though the odds ratio was in the expected direction (Exp[B] = 1.45). Similar to the aggregate model, the time frame of *06:00–11:59* (Exp[B] = 1.96) and *attack status* (Exp[B] = 2.01) were statistically significant and associated with increased likelihood of an unsuccessful attack. *Weapons present* (Exp[B] = 0.22) and *number of pirates* (Exp[B] = 0.97) were associated with a decreased likelihood of an unsuccessful attack.

Shane *et al. Crime Sci (2015) 4:21*

Page 8 of 13

Table 3 Aggregate SCP analysis: mixed-effect logistic regression (n=2638)

Variables	Odds ratio [Exp(B)]	SE	z	p	95% CI for Exp (B)	
					Lower	Upper
SCP indices						
Increased risk	2.80	0.27	10.85	0.00	2.33	3.37
Increased effort	2.71	0.44	6.18	0.00	1.98	3.72
Control[a]						
00:00–05:59	1.11	0.20	0.60	0.55	0.78	1.58
06:00–11:59	2.21	0.59	2.96	0.00	1.31	3.74
12:00–17:59	1.19	0.35	0.58	0.56	0.67	2.10
Weapons present	0.27	0.04	−8.76	0.00	0.20	0.36
Vessel status	2.20	0.41	4.30	0.00	1.54	3.16
Vessel type	0.98	0.16	−0.14	0.89	0.71	1.35
1 Qtr.	1.44	0.30	1.78	0.07	0.96	2.16
2 Qtr.	0.99	0.20	−0.06	0.95	0.66	1.48
3 Qtr.	0.95	0.20	−0.23	0.82	0.64	1.43
Number of pirates	0.97	0.17	−1.71	0.09	0.94	1.00
Year	0.98	0.02	−1.04	0.30	0.94	1.02
Model						
Constant	1.44e+19	6.20e+20	1.02	0.31	2.90e−18	7.12e+55
Log likelihood	−594.69					
Wald χ^2 (*p*)	245.91 (*0.00*)					

The model assumes an unstructured covariance structure to account for the presence of correlation between the random slopes and random intercepts

Listwise deletion of cases

[a] Reference category for time range controls is 18:00–23:59. Reference category for quarter controls is 4 Qtr.

Table 4 Aggregate likelihood-ratio (LR) tests: random-intercept vs. random-intercept-and-slope models

Model comparison[a]	LR χ^2	p
Increased risk random intercept-and-slope	9.89	0.01
Increased effort random intercept-and-slope	19.62	0.00

[a] The specified random intercept-and-slope models are compared to the random intercept model

Table 6 displays the results of the disaggregate likelihood-ratio tests. The majority of techniques did not achieve statistical significance. The lone exception was *alarm raised* ($p = .02$), suggesting a heterogeneity effect across continents. Figure 2 displays the odds ratios for *alarm raised* across continents. While the effect of *alarm raised* significantly differed, odds ratios were greater than 1 in each instance, showing that the technique was associated with an increased likelihood of an unsuccessful attack within each continent. Odds ratios ranged from a low of 1.90 in the case of the Americas to a high of 4.33 in the case of South East Asia.

Discussion and policy implications

This study's findings support the application of SCP techniques aimed at increasing the effort and risk to reduce successful pirate attacks across continents. As discovered in the aggregate analyses, both indices of increasing the risk and increasing the effort were found to be effective at reducing successful attacks on a global level. However, some differences were found across continents. While increasing the effort had the same effect at reducing unsuccessful attacks across all regions, increasing the risk varied in its effect across continents. Specifically, the use of multiple *Increased Risk* tactics was associated with an increased likelihood of unsuccessful attacks in South East Asia, Far East, and Rest of the World, and a decreased likelihood in the Americas, Africa, and the Indian Sub-Continent. This suggests that the vulnerability of pirates to cumulative SCP measures significantly differs across continents.

The disaggregate analyses expanded on these results, revealing that all the SCP techniques that increase risk, except for anti-piracy watch, were associated with more unsuccessful attacks. Furthermore, the effect of all but one disaggregated tactic was consistent across continents. That lone tactic was *alarm raised;* however, alarm raised odds ratios were above 1 for all continents, meaning that the continents differed in terms of the magnitude of prevention, not whether prevention was achieved. This indicates that the techniques of alarm raised, watchman
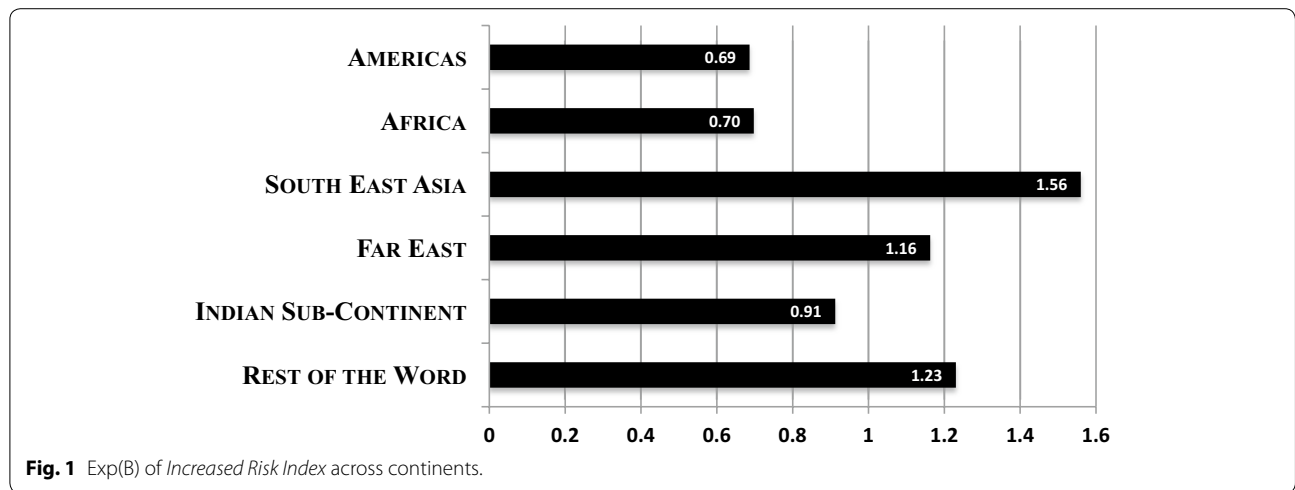
Shane *et al. Crime Sci* (2015) 4:21

Page 9 of 13

Fig. 1 Exp(B) of *Increased Risk Index* across continents.

Table 5 Disaggregate SCP analysis: mixed-effect logistic regression (n=2638)

Variables	Odds ratio [Exp(B)]	SE	z	p	95% CI for Exp (B)	
					Lower	Upper
Increased risk						
Alarm raised	4.33	0.74	8.60	0.00	3.10	6.04
Watchman present	1.84	0.30	3.72	0.00	1.33	2.53
Anti-piracy watch	1.24	0.31	0.85	0.40	0.75	2.03
Private security	9.23	3.85	5.33	0.00	4.07	20.90
Increased lighting	8.77	4.90	3.88	0.00	2.92	26.24
Increased effort						
Evasive maneuvers	26.81	20.26	4.35	0.00	6.10	117.92
Crew mustered	1.76	0.32	3.11	0.00	1.23	2.52
Control[a]						
00:00–05:59	1.04	0.18	0.22	0.83	0.74	1.47
06:00–11:59	2.01	0.53	2.64	0.01	1.20	3.38
12:00–17:59	0.99	0.29	−0.03	0.98	0.55	1.77
Weapons present	0.24	0.04	−9.31	0.00	0.18	0.33
Vessel status	2.05	0.38	3.87	0.00	1.42	2.95
Vessel type	0.94	0.15	−0.42	0.67	0.68	1.29
1 Qtr.	1.50	0.30	2.02	0.04	1.01	2.23
2 Qtr.	1.02	0.21	0.12	0.91	0.69	1.52
3 Qtr.	1.06	0.21	0.27	0.78	0.71	1.57
Number of pirates	0.97	0.02	−1.91	0.06	0.94	1.00
Year	0.90	0.02	−5.32	0.00	0.87	0.94
Model						
Constant	4.42e+88	1.70e+90	5.31	0.00	8.50e+55	2.3e+121
Log likelihood	−618.86					
Wald χ^2 (*p*)	269.59 (*0.00*)					

The model assumes an unstructured covariance structure to account for the presence of correlation between the random slopes and random intercepts

Listwise deletion of cases

[a] Reference category for time range controls is 18:00–23:59. Reference category for quarter controls is 4 Qtr

Shane *et al. Crime Sci* (2015) 4:21

Page 10 of 13

Table 6 Disaggregate likelihood-ratio (LR) tests: random-intercept vs. random-intercept-and-slope models

Model comparison[a]	LR χ²	*p*
Alarm raised random intercept-and-slope	8.61	0.01
Watchman present random intercept-and-slope	0.70	0.40
Anti-piracy watch random intercept-and-slope	0.45	0.80
Private security random intercept-and-slope	1.59	0.45
Increased lighting random intercept-and-slope	0.04	0.98
Evasive maneuvers random intercept-and-slope	1.52	.47
Crew mustered random intercept-and-slope	2.95	.23

[a] The specified random intercept-and-slope models are compared to the random intercept model

present, private security, and increased lighting can and should be applied in all regions to prevent successful attacks.

Overall, the findings lend support to the SCP notion regarding the importance of being crime-specific when formulating and implementing possible measures aimed at preventing and disrupting crime (Clarke 2013). As detailed in the literature review, piracy varies in form depending on the region. Thus, some SCP techniques may have a larger positive effect at reducing attacks in certain regions than others. For example, raising the alarm had a larger effect in South East Asia compared to the other regions, indicating that this technique may need to be emphasized and utilized more in South East Asia than in other regions. Perhaps pirates in South East Asia are more threatened by a ship's alarm given the fact that they tend to operate closer to shore (Von Hoesslin 2012) and are usually armed with knives or crowbars instead of guns (Nincic 2009; Sullivan 2010). This may make them feel more susceptible to being apprehended when an alarm sounds.

Perhaps the most important policy implication is that despite the pirates' personal position or whether they are

armed, the prospect of an unsuccessful attack is more likely when layers of *increase effort* measures are implemented. These measures have added importance when vessels are at anchor or in port, where guardianship may be lower due to over-extended or corrupt police forces and the realities associated with failed or weak states' ability to provide protection. The findings also imply that shipping vessels do not necessarily have to arm themselves, which may escalate an attack, nor rely on government to protect them while at sea. What makes SCP so appealing is that shipping companies can become more self-reliant and avoid implementation issues associated with multiple agencies.

However, we also acknowledge the somewhat paradoxical relationship between the findings of the *aggregate* and *disaggregate* analyses, specifically with regards to the *increased risk index*. The disaggregate analysis found that each individual SCP technique significantly increased the likelihood of unsuccessful attacks on a global level. Across continents, *alarm raised* differently impacted piracy, but was associated with increased likelihood of unsuccessful attacks in each instance. Therefore, while some heterogeneity was evident with this technique, it can be classified as an effective crime control tactic in each instance. A different picture emerged when we analyzed the use of multiple techniques in the aggregate analysis, via the *increased effort* and *increased risk* indices. While both *increased effort* and *increased risk* were associated with increased likelihood of unsuccessful attacks on a global level, the *increased risk index* was associated with unsuccessful attacks in only 3 of the 6 continents included in this study (South East Asia, Far East, an Rest of the World). In the Americas, Africa, and Indian Sub-Continent, the *increased risk index* was actually associated with a decreased likelihood of an unsuccessful attack. This implies an interesting relationship between the different SCP techniques as they relate to
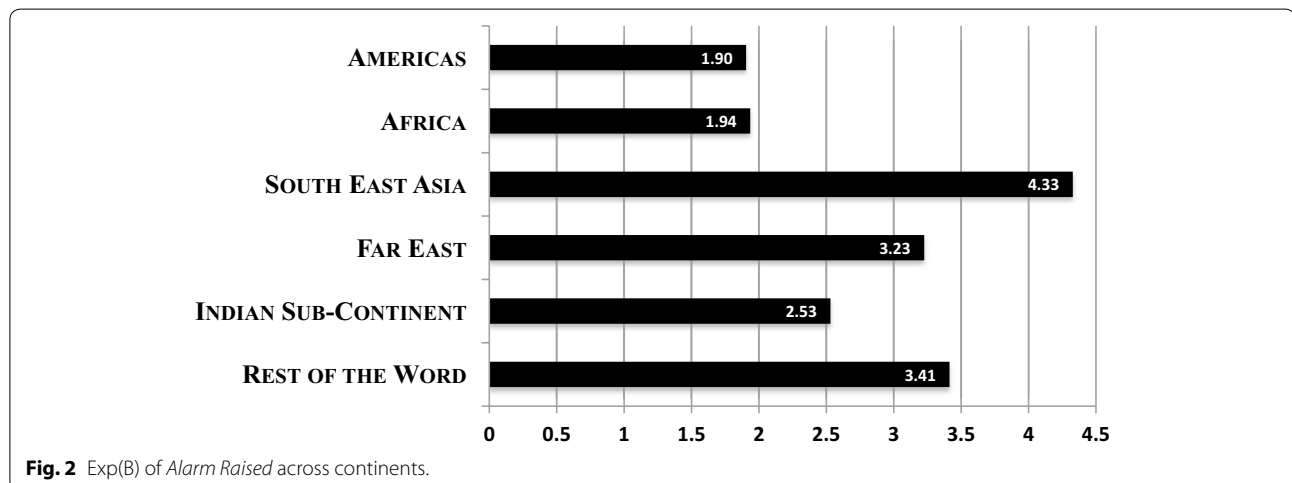

Fig. 2 Exp(B) of *Alarm Raised* across continents.

Shane *et al. Crime Sci* (2015) 4:21

Page 11 of 13

piracy. In particular, while each individual tactic on its own increases the likelihood of unsuccessful attacks, the combination of various tactics does not always work as intended. Future research should aim to better understand the combination of tactics that best prevent piracy attacks. Indeed, Bryant et al. (2014) recently found that the use of Watch Keeping and Enhanced Vigilance (WK and EV) in addition with other tactics was more effective than any combination of tactics absent WK and EV. Future research should continue to explore these issues.

Limitations and directions for future research
Limitations
Reporting piracy to the IMB is voluntary so there may be some measure of underreporting due to potential insurance costs, image and reputation of the shipping company and heightened perception of risk among shipping clientele. Counting piracy incidents depends on the definition; different definitions do exist such those offered by the 1958 Geneva Convention on the High Seas (Article 15) and the 1982 United Nations Convention on the Law of the Sea (UNCLOS) (Article 101), which may not include theft so the full extent of piracy and economic losses may not be fully captured. The data published by the IMB in their annual report are summary data and may also contain errors due to collection and reporting processes (Jacob 1984). Some of this was evident in the yearly data, which is why data before 2000 was not included. The SCP principles may also suffer from "… unavoidable overlap among categories" (Clarke 1997, p. 17), which may introduce a degree of measurement error. In addition, the analysis did not account for characteristics of the crew operating the under-attack vessels, which may be related to the likelihood of unsuccessful attacks. Certain ship crews may be more experienced in combating piracy, and may more effectively incorporate SCP techniques. Therefore, crew-specific variables may have an interaction effect with certain SCP tactics and may alter the findings of the analysis if measured.

Directions for future research
Despite these limitations, this study contributes to the literature on piracy prevention by illustrating how different SCP tactics, and magnitudes of tactics, perform against piracy on both a global and continental level. Future research can expand on these findings and explore whether the effectiveness of the SCP measures vary at the country level. In addition, future studies can test how the techniques relating to increasing the risk and increasing the effort vary depending on particular attack characteristics, such as the type of piracy involved (e.g., opportunistic theft vs. ransom) as well as the type of pirate weapons present (e.g., lack of weapons, firearms, knives).

At a basic level, opportunity is present in all crimes and facilitated by illicit opportunity structures and exploited by weaknesses in social control. Theories of crime and criminality from other disciplines such as political science and international relations can provide a framework of the social and environmental processes that promote and sustain piracy on land.

Conclusion
Overall, the theory is supported. When measures to increase risk and effort are applied, there is a statistically significant increase in unsuccessful pirate attacks, after controlling for other influences. For each additional tactic employed that increases risk or increases effort, there is an increase of more than twofold for unsuccessful attacks. In general, the findings imply that SCP can be applied on the water, where help is not readily available. The measures can be applied without resorting to firearms, which may only escalate an encounter with pirates. The SCP measures identified here can be incorporated into the planning and operational practices of the shipping industry for ship operators and masters transiting high-risk waters worldwide.

Endnotes
[a]A safe room is a fortified space aboard a ship designed to protect the crew if pirates board the vessel.

[b]https://www.icc-ccs.org/piracy-reporting-centre.

[c]Shane and Magnuson (2014) conceptualized Crew Mustered as the lone Reduce the Anticipated Rewards measure in their study. We re-conceptualized this measure as part of the Increase Effort category so that it better fit with the other variables and research question. While this approach differed from Shane & Magnuson's, it still strongly adheres to the SCP principles. For one, having to breach a fortified room to take a crew hostage indeed increases the required effort for obtaining a ransom. Also, the differing approaches reflect the unavoidable overlap inherent in the opportunity-reducing techniques of SCP (Clarke 1997, p. 17).

[d]STATA version 13 was used to conduct all statistical analyses for this study.

[e]A Tolerance value of .01 or less generally indicates the presence of multicollinearity. Tolerance scores ranged from .623 to .990. The Variance Inflation Factor (VIF) score is the reciprocal of Tolerance and VIF scores that exceed 10 indicate multicollinearity. VIF scores range from 1.01 to 1.61 (Meyers et al. 2006, p. 212).

[f]Two of the disaggregated SCP variables, Increase Speed and Electric Perimeter Fence were excluded from the disaggregated models because the models failed to converge when these variables were included as random effects, due to a lack of variance across continents. Given

Shane *et al. Crime Sci (2015) 4:21*

Page 12 of 13

this observed lack of variance, the variables were dropped from the model (Hamilton 2013, p. 404).

ᵍThe exponential of the slope (Exp[B]) rather than the slope (B) is presented to allow for easy comparison with the logistic regression model findings.

Authors' contributions
The abstract was written by JS and edited by EP. The introduction was written by JS. The literature review as written by MM and edited by JS. The theoretical framework was written by JS and MM. The methodology and analysis were written by EP and edited by JS. The results were written by EP. The discussion and policy implications were written by JS, EP and MM. The limitations and directions for future research were written by JS, EP and MM. All authors read and approved the final manuscript.

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Compliance with ethical guidelines

Competing interests
The authors declare that they have no competing interests.

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Shane *et al. Crime Sci (2015) 4:21*

Page 13 of 13

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