Space-Time Pirate Attacks Analysis

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February 27, 2012

1 Abstract

The paper examines space-time patterns of maritime piracy around the Horn of Africa. Using rational choice theory and optimal foraging theory as the theoretic frame, six years of recorded pirate attack data were used to test whether spatial and temporal attack patterns were independent. The results indicate evidence for a communicability of risk, that is pirate activity clusters in space *and* time. Incorporating this finding means that forecasting of high risk areas could be made more effective. The theoretical implication is that pirates' target selection appears to be consistent with other crime types, such as burglary, car crime and shootings. The results have implications for informing maritime piracy prevention and suppression efforts.

2 Introduction

Maritime piracy has attracted widespread international and media attention in recent years, with increased volume of attacks and escalating ransom demands. The Gulf of Aden and Horn of Africa, the current area of concern, host a perfect storm of criminogenic factors. Somalia, a failed state since 1991, has no functioning capacity to deter to would-be pirates, has a long history of internal conflict (and therefore a plentiful supply of weapons) and is economically unstable. These contribute to provide a ready supply of young males ripe for recruitment into criminal organisations. The area borders the Suez Canal, one of the busiest shipping lanes in the world (Sullivan, 2010; Vrey, 2010; West et al., 2010). Trade volumes have increased exponentially over the last decade, with UN economists indicating that shipping traffic has grown tenfold since 1980, and is (conservatively) set to double from 2007 levels by 2015 (UNESCAP, 2007). In sum, an ostensibly limitless supply of high value targets pass by economically disadvantaged young men with little legitimate source of deterrence.

The 'plunder' of successful attacks can range from meagre, such as ship's stores and small amounts of cash, to crew members and more expensive items, to even the entire ships, held to ransom or even stolen to be used as weapons in the pirate arsenal (Pelton, 2011). While the financial burden on individual operators is highly variable, the impact in the aggregate, however, is momentous. In 2008 Lloyds Joint War Committee declared the Gulf of Aden a "war risk area", leading to increased insurance premiums (Giampaolo and Foster, 2011). The Suez Canal Authority have reported a reduction in Canal traffic of nearly 50 percent since the upsurge in pirate activity (Bendall, 2010). Shipping companies too have felt the pressure of piracy; Giampaolo and Foster (2011) report a trend in companies re-routing around the Cape of Good Hope to avoid travelling through pirate hot spots, incurring additional costs of almost US$30,000 per day for the 5-day detour (Bendall, 2010). Alternatives to re-routing include hiring private (armed) security to accompany ships through high-risk routes (roughly one in ten ships transiting the Gulf of Aden employs private security (Giampaolo and Foster, 2011)).

The rapid escalation of pirate activity in 2008–09 led the UN Security Council to pass a series of resolutions (UNSCR 1816, 1846 and 1851) aimed at re-defining the circumstances in which nation states were permitted to interdict vessels in international waters. This resulted in joint naval operations involving US-led, EU-led and NATO deployments patrolling for pirates and escorting convoys of ships through high risk areas. However, the vast expanse of the ocean in question means that ensuring "a presence" is not

realistic. In fact, Percy and Shortland (2009) argue that the deterrent effect of naval patrols is ephemeral, limited to about 48 hours.

The purpose of this study is to demonstrate that space-time patterns of pirate activity exist. If present, these patterns can be used as a form of operational intelligence in order to disrupt or prevent pirate attacks. To the best of our knowledge, this research is the first examination of space-time patterns of maritime piracy. As such, it provides an opportunity to determine if well-established spatio-temporal behaviours common in volume crimes (burglaries, car crime, shootings) in urban settings are the same for maritime piracy, which obviously has a very different operating environment.

3 Literature Review

Piracy is a widely used term that has garnered a significant amount of implications and stereotypes in addition to its practical definition (Bendall, 2010; Schofield, 2010). The International Maritime Organisation (IMO) defines piracy as:

> (a) any illegal acts of violence or detention, or any act of depredation, committed for private ends by the crew or the passengers of a private ship or a private aircraft, and directed:
>
> > (i) on the high seas, against another ship or aircraft, or against persons or property on board such ship or aircraft;
> >
> > (ii) against a ship, aircraft, persons or property in a place outside the jurisdiction of any State;
>
> (b) any act of voluntary participation in the operation of a ship or of an aircraft with knowledge of facts making it a pirate ship or aircraft;
>
> (c) any act inciting or of intentionally facilitating an act described in sub-paragraph (a) or (b)" (Sullivan, 2010).

This definition, adopted by the UN Convention on the Laws of the Sea (UNCLOS), is consistent with international law as it expressly precludes acts occurring with any States' jurisdiction[1]. For the purposes of this article, the IMO definition of piracy–attacks that occur on the high seas or outside of the legally-recognised jurisdiction of any state–will be used.

Relatively few attempts have been made to explain the pirate phenomenon using criminological or behavioural-based micro explanations (Shane and Lieberman (2009) is a notable exception). Rather, much of the literature currently focuses upon the political structure (or lack thereof) in Somalia (Chalk, 2010; Ramsey, 2011a; Sterio, 2011), international law and the challenges of prosecution (Chalk, 2010; Guilfoyle, 2010; Kraska and Wilson, 2009; Ramsey, 2011b; Sterio, 2011), maritime security (Chalk, 2008, 2009; Ewence, 2011; Giampaolo and Foster, 2011; Kraska and Wilson, 2009; Little, 2011; Myburgh, 2002; Nincic, 2002, 2005; Pringle, 2011; Renwick and Abbott, 1999; Vrey, 2010; West et al., 2010) and economic impacts of piracy[2] (Bendall, 2010; Bowden, 2010; Carney, 2009; Gilpin, 2009; Min, 2011; Myburgh, 2002; Sullivan, 2010).

For example, Guilfoyle (2010) observes the problem from two different theoretical viewpoints: pirates as combatants or criminals. The combatant viewpoint considers acts of piracy, on Western ships in particular, as forms of marine terrorism or even political activism. This is consistent with other theorists, including Schofield (2010) and Sterio (2011), in that the political climate of areas such as Puntland[3] have a history of plying host to violence and wars over independence and undue Western influence in the region, spanning back before the resurgence of Somali piracy. Hijacking ships and either demanding ransom or commandeering the vessel brings about international attention and thus raises awareness to the political cause.

[1] There exists another definition in the literature. The International Maritime Bureau (IMB) defines piracy as "the act of boarding any vessel with an intent to commit theft or any other crime, and with an intent or capacity to use force in furtherance of that act" (ICC International Maritime Bureau, 2011, p. 3). This includes any act of robbery or violence against a ship either docked or steaming. As the focus of the analysis is on pirate activity on the high seas, the IMB definition is not used.

[2] Leeson (2007) provides an interesting micro-economic treatment of the structure, governance and operating practices of pirate gangs.

[3] Puntland, on the northeastern tip of Somalia, is a self-declared autonomous state and widely regarded as the stronghold of pirate gangs.

The second definition (as criminals) looks to judge piracy as having motives based around the economic climate of countries such as Somalia. Somalia's GDP is significantly lower than many other third-world countries (Pham, 2010) and the absence of a sovereign government means there is little in the way of domestic deterrence or punishment (Pelton, 2011). Against this is the reality that the returns from hijacking vessels are very lucrative, providing for numerous families, as well as bribes and gratuities to local authorities for landing rights to stow ships in staging posts and to re-invest the funds into the community (Chalk, 2010; Nincic, 2009). For instance, Kraska and Wilson (2009) observe that the average haul from a successful attack per pirate amounts to over two years salary.

The theoretical framework employed in this study is rational choice theory (Cornish and Clarke, 2008, 1986). This theory explains how offenders choose which criminal opportunities to exploit in a given situation. Offenders have certain goals and desires and evaluate their environment for opportunities that best meet these. This opportunity evaluation is a type of utility maximisation, criminal opportunities are assessed on the perceived ease of exploitation, likely risk of apprehension and anticipated benefit. Offenders have limited resources (time, personnel, equipment) so cannot afford to randomly select targets.

Recent research in space-time patterns of crime (Bernasco, 2006; Bernasco and Block, 2009; Bernasco and Nieuwbeerta, 2005; Johnson et al., 2009a,b, 2007a; Johnson and Bowers, 2004) has borrowed the concept for *optimal foraging* from wildlife ecology. Animals seek to locate and kill prey by minimising effort (distance travelled, time expended, effort exerted), minimising the risks of injury or death while securing sufficient nourishment for survival. The analogy between predators efficiently locating food sources and offenders locating suitable targets are clear, but incorporating the optimal forager principle with rational choice theory provides additional insight into spatial crime patterns (see Johnson et al. (2009b) for a detailed treatment). One useful implication is that crime will tend to cluster in space *and* time, the so-called *near repeat process* (Johnson et al., 2007b; Townsley et al., 2003). Near repeats are said to reflect a communicability of risk; there is an elevated risk of future crime within a given distance and time from previous events. As such the presence of near repeats allows better prediction of future crime patterns than simple (and conventional) retrospective methods of forecasting (Johnson et al., 2009a, 2007c). The focus of this article is to investigate whether space-time patterns of pirate activity exist. If clusters of attacks in time and space become apparent, it would confirm that the decision-making of pirates are consistent with rational choice theory. By drawing such conclusions, new methods of prevention and deterrence could be developed.

4 Data

To investigate the research question, six years of pirate activity were obtained from the International Maritime Bureau's annual reports on piracy (ICC International Maritime Bureau, 2006, 2007, 2008, 2009, 2010, 2011). These contain worldwide incident level data of reported pirate attacks against ships. Each observation contains information about the date, time and location of the incident, ship details (name and type of vessel) and a short narrative account. For the purpose of the analysis presented here we only concentrate on incidents occurring around the Horn of Africa. As the operating range of Somali pirates has increased in recent years, the study region for this analysis was the area bounded by –7 and +23 degrees latitude and +40 and +63 degrees longitude. In addition, we restricted our analysis to pirate activity on the high seas and excluded incidents in port (consistent with the IMO definition of piracy). After omitting a small number of cases with incomplete date, time or location information, the sample consisted of 508 incidents across calendar years 2006 to 2011 inclusive.

The IMB annual reports distinguish incidents as attempts from successful attack. The latter are incidents where pirates managed to board the targeted vessel. The terminology used in the analysis will be to refer to pirate activity as both attempts and successful attacks, but these will be partitioned and presented separately where there is a significant difference.

5 Methodology

The Knox technique (Knox and Bartlett, 1964) has been used in other research to investigate the communicability of burglary risk (Johnson et al., 2007b), shootings (Ratcliffe and Rengert, 2008; Wells et al., 2011; Youstin et al., 2011), insurgent activity (Braithwaite and Johnson, 2011; Townsley et al., 2008) and recently terrorism (Behlendorf et al., 2011; LaFree et al., 2011). The approach is as follows: for a set of

data, each observation is compared with every other (n cases generates $\frac{n(n-1)}{2}$ pairs) and the space and time difference of each pair is computed[4]. A contingency table is generated to summarise the distribution of pairs at various space-time intervals. It can be concluded that some form of communicability exists if many more pairs are observed to occur closer in space and time than would be expected on the basis of chance.

The expected distribution is generated from the data through a resampling procedure. The observed data is treated as one realisation and randomly allocating dates among locations allows other realisations to be created. A total of 999 realisations were created to form an expected distribution. The observed distribution is added to make a sample size of 1,000. The observed frequency for each cell is compared to what would be expected on the basis of chance, which allows a P-value to be calculated for every cell. This is the probability of obtaining the observed results if the null hypothesis–space-time independence–is true. The inferential test is one sided, meaning that only departures from expectation in a certain direction are of interest. As the analysis presented here is exploratory, we chose a range of space-time thresholds to locate these departures from space-time independence.

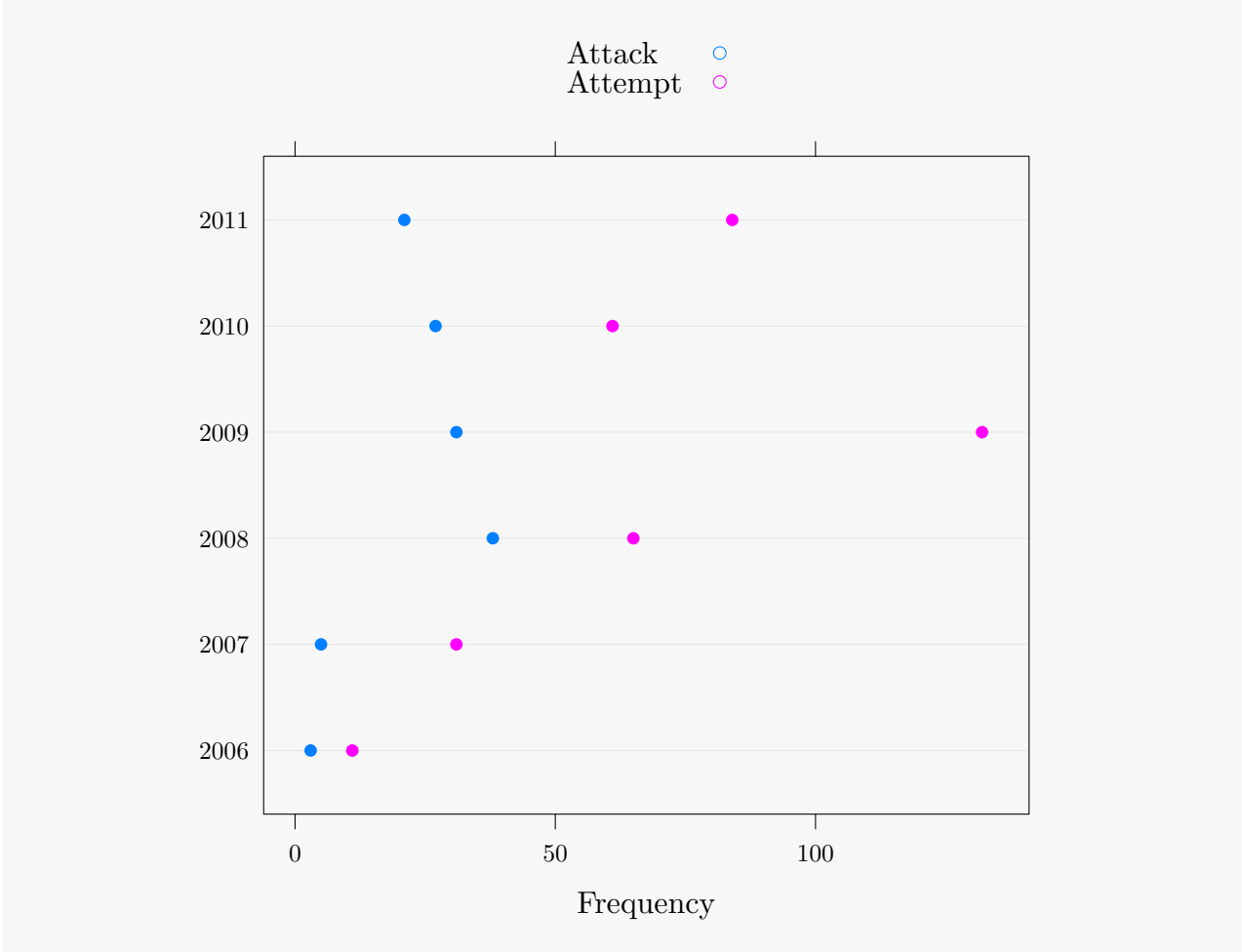
The resampling test means that, unlike many tests of spatial clustering, complete spatial (or temporal) randomness is assumed not to be a feature of the expected distribution. Events are expected to cluster in some places more than others and this is accounted for in the analysis (by restricting the expected distribution to the space and time value of the sample data). This is an advantage over many previous studies of maritime piracy that have not accounted of the opportunity structure of the problem. Attacks against ships can only be carried in the intersection of shipping lanes and the geographic range of the attack vessels.

6 Results

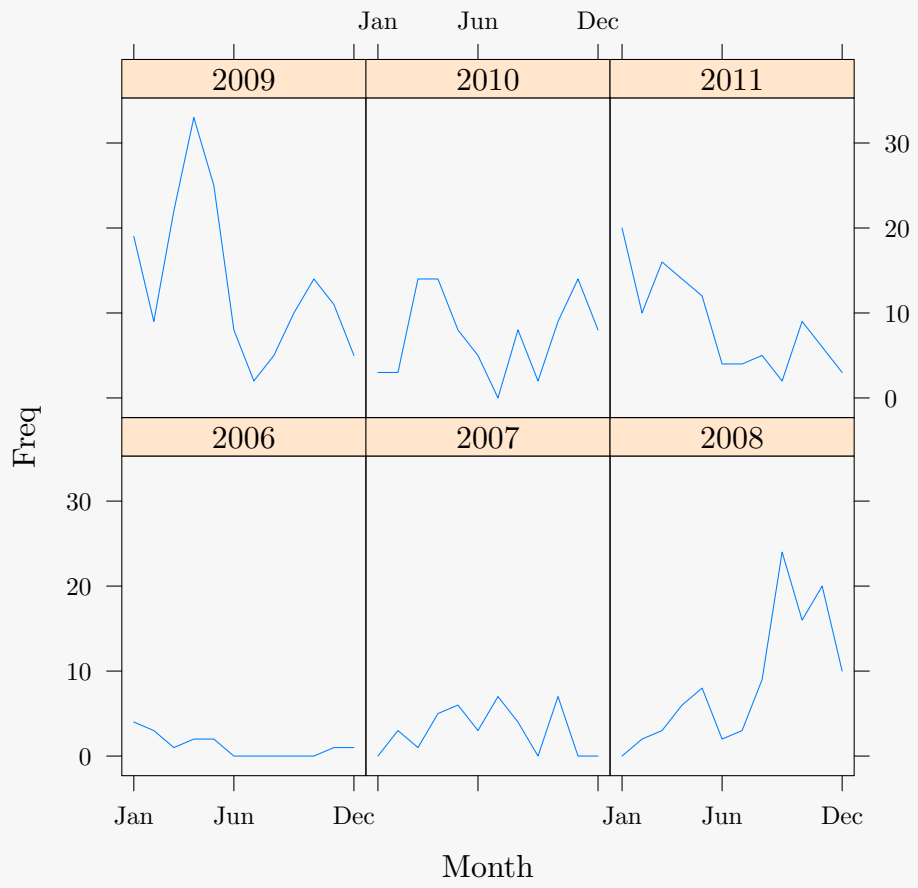
Temporal and spatial patterns of pirate activity were examined separately prior to testing for space-time independence.

6.1 Temporal patterns

[4]Due to the extent of the study region, Great Circle distances were calculated rather than Euclidean distance as the former accounts for the the curvature of the Earth (which becomes important when the distance between two points is sufficiently large).

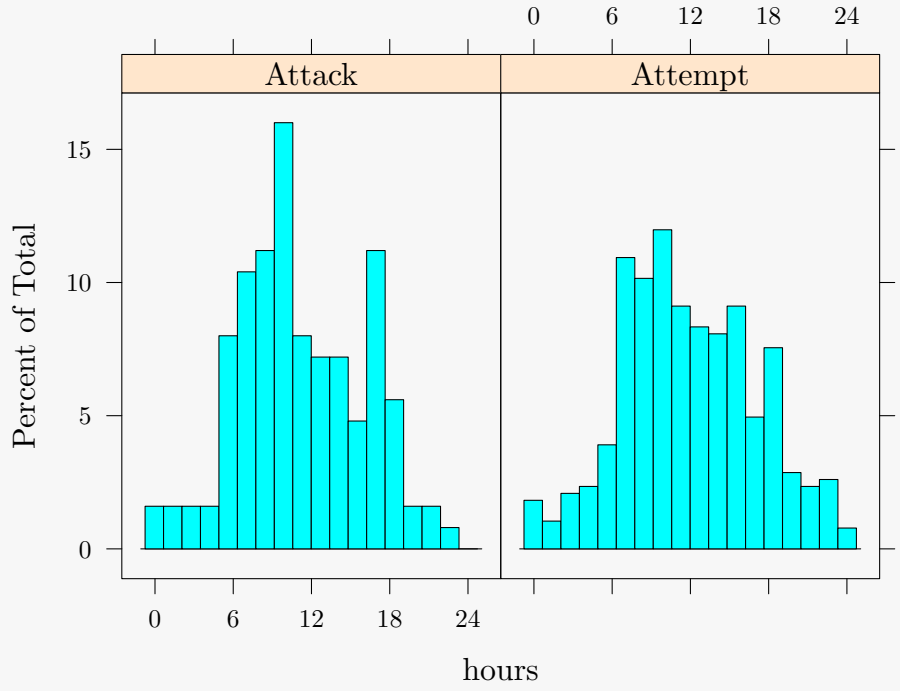


Figure**??** shows the levels of pirate activity per year. Attempts are far more frequent than successful attacks, for all years. 2009 had the highest volume of reported Somali pirate activity with 163 incidents in total. 2008 had the largest number of successful pirate attacks in a single year (38) as well as the highest proportion of successful attacks (0.58). The number of successful pirate attacks has been decreasing since 2008.

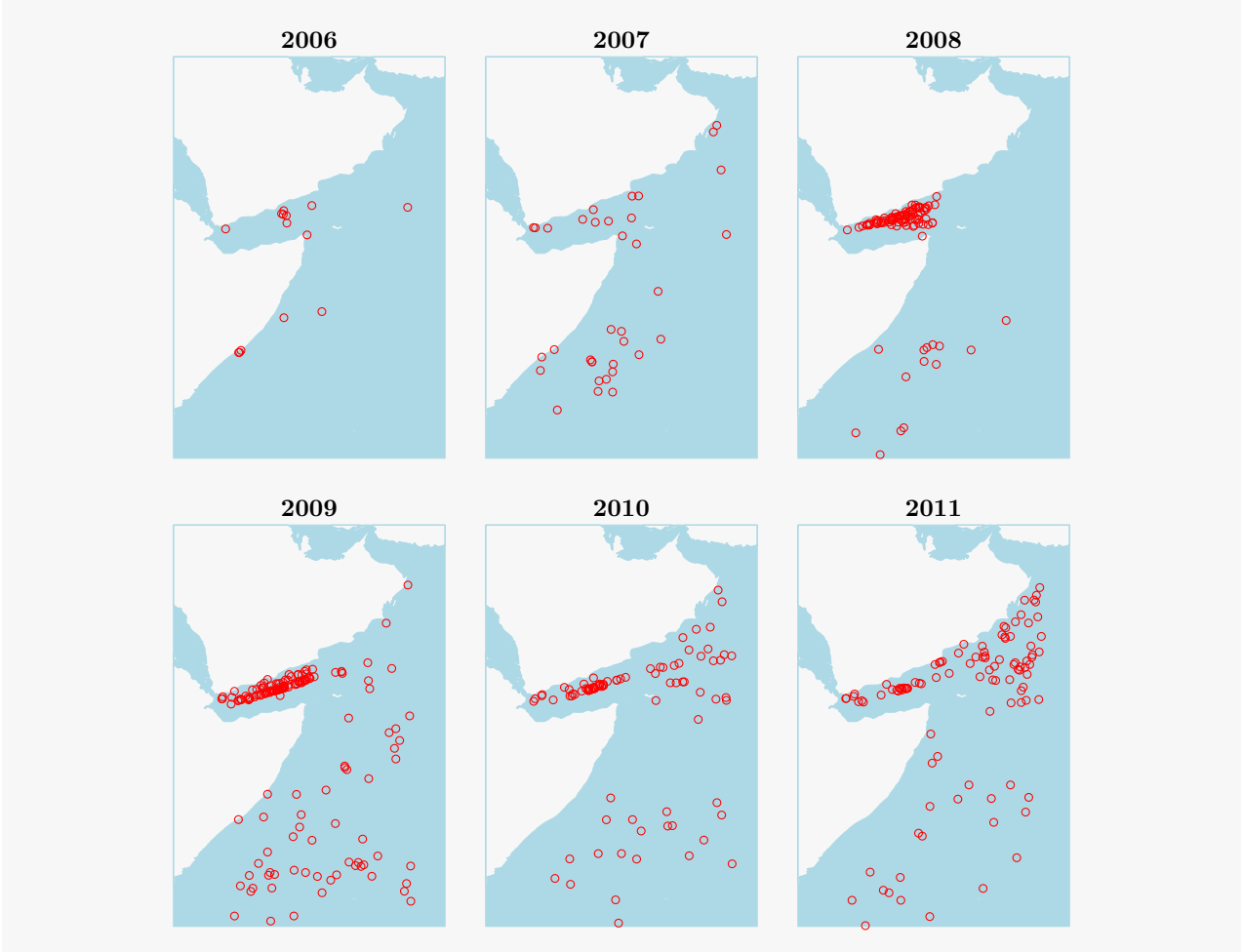


Figure**??** displays the level of pirate activity monthly, providing a more revealing depiction of the increase than Figure**??**, because there is evidence of both seasonality as well as a long-term trend in the data (no difference in these patterns was observed when partitioned into attempts and attacks). The seasonal pattern suggests that pirate activity is relatively low in summer months (except 2007). The long-term trend shows an increase in pirate activity from the middle of 2008 to the first quarter of 2009. UN Security Council Resolutions 1816, 1846 and 1851 (expressly permitting states to deploy tactics designed to suppress Somali-based piracy and armed robbery) were adopted in late 2008 in response this sharp rise. The activity levels in 2010 and 2011 mimic those of other years with respect to seasonal patterns, but the peak levels are diminished.

Examining pirate activity by time of day reveals a distinct risk profile, shown in Figure**??**. High risk periods are restricted to daylight hours. There is a slight skew for successful attacks to mid-morning with the peak time for attack just prior to midday. The time profile of attempted attacks is, for the high risk period, more uniformly distributed.



6.2 Spatial patterns



Figure?? shows the spatial distribution of pirate activity. There is an obvious increase in the operational range of pirates which accelerated from 2009 onwards. 2008 and 2009 display intense levels of activity in the Gulf of Aden, which has dispersed in 2010 and 2011. This finding suggests that joint naval deployments operating in the area[5] pirates have been deterred from targeting ships and have needed to travel further afield to locate suitable targets. While an formal evaluation of these operations is beyond the scope of this article, these patterns are highly suggestive that the naval deployments have had a non-trivial suppressing effect on pirate activities, especially considering the aggregate activity levels of pirates is lower in 2010 and 2011 than the preceding two years. While displacement is traditionally used to imply the futility of blocking opportunities, it seems evident that there has been a net reduction in the volume and concentration of pirate activity. Pirates are forced to expend more effort or face greater risks to satisfy their material needs. We found no evidence of differences in spatial patterns of attempts compared to successful attacks.

6.3 Near repeat patterns

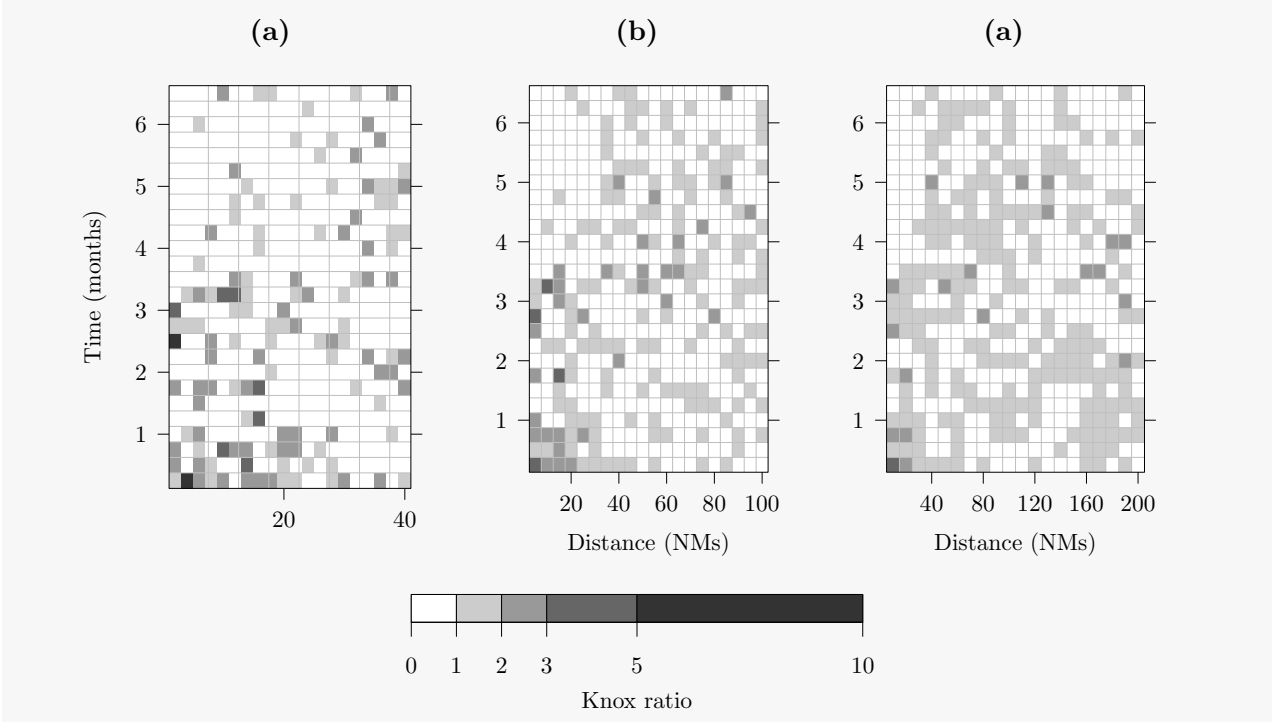
The Knox test was conducted to explore whether the risk of pirate activity was communicable and Figure refnrplot contains a graphical depiction of the results. Each cell represents a space-time combination and is shaded according to whether the P-value of that cell is less than 0.05. The extent of shading is determined by the ratio of observed to expected pairs (the Knox ratio). Combining statistical significance and effect size in one graph ensures that the observed results are meaningfully significant, as Type II errors (small differences that appear significant) are avoided.

[5]Operation ATALANTA (EU-led) commenced December 2008 and Combined Task Force 151 (US-led) commenced January 2009

For any particular cell we are only concerned with the identification of excessive event pairs; that is, instances where there are more pairs than we would expect if we assumed the location and timing of pirate activity were unrelated. It should be noted that pairs of incidents with no spatial distance (attacks at the same location) have been excluded from the analysis, as have pairs of incidents that occurred on the same day as each other.

Time increments between event pairs are constant across the figures but differ for space. The finest resolution of analysis is displayed on the left, with each grid corresponding to 2 nautical miles, and the largest resolution to the right, each grid corresponding to 10 nautical miles.

The trends are consistent and enumerate the distances and times over which these patterns emerge. For the period of time studied, the risk of pirate activity appears to have communicated to nearby locations for a short period of time, regardless of the level of resolution. The communicability threshold appears to vary according to the bandwidths selected, a reflection that parameters chosen influence output. At the finest level of spatial resolution (leftmost plot) the highest risk of future pirate activity is a distance of up to 10 nautical miles for a period of 1 week after prior pirate activity. The communicability thresholds increase out to 20 nautical miles and 3 weeks (middle plot) and 30 nautical miles and 4 weeks (rightmost plot) when the spatial resolution is increased to 5 and 10 nautical miles respectively. The implications of the different thresholds will be discussed the the next section.



7 Conclusions

Crime patterns are important because they reveal aspects of offender decision-making. Rational choice theory suggests that offenders will attempt to satisfy their needs in the simplest and least risky ways possible. The power of spatial patterns of crime is that they reveal *where* these opportunities are located.

This article has demonstrated that space-time patterns of maritime piracy exist and replicates many of the findings previously established relating to crimes such as burglary, vehicle crime, assaults and shootings. This similarity is, we think, instructive. It suggests that the decision-making calculus of pirates is consistent with other types of offending. Pirates appear to be rational decision-makers attempting to minimise the risks they face and adapting to changing opportunities. By examining near-repeats and clusters of attacks in similar timeframes and geographical locations, it can be theorised that pirate activity

is deliberate and opportunistic: significant clusters in space and time would add credence to the theory that pirate activity is influenced by the available resources and targets.

How can this information be used to disrupt pirate activity? According to routine activity theory, two actors–guardians and place managers–are primarily responsible for the prevention of crime. Information on the future risk of pirate activity should, therefore, be used to inform the decisions and actions of guardians and place managers.

Ship captains and crew serve as guardians because they can implement anti-piracy measures most directly (such as the Best Management Practises outlined by UK Maritime Trade Operations (2011)). The International Maritime Organisation could use this information to develop much more precise risk maps of pirate activity, and provide advice to ships entering risk prone areas. The combined area associated with elevated risk would be much more focused than existing intelligence products, thus are likely to be more effective. The reporting regime of pirate attacks is such that this form of intelligence can be automated to provide a real-time risk map.

The joint naval operations in the region currently act as a form of place management; they patrol international waters and lead convoys of commercial and humanitarian cargo through the area. Communicability of pirate activity can therefore be used to plan both patrols and convoys. Patrols should be deployed to be in the areas associated with the highest risk and convoys routed to avoid them. This has already been implemented for burglary in the UK (Johnson et al., 2009a), to positive effect.

The analysis conducted here is not without limitations. The data used are pirate activity as reported to the IMB. Some reports suggest that a sizeable portion of pirate attacks, as much as 50 percent go unreported for fear of increased insurance premiums or reprisals from pirates (Torchia, 2009). However, this proportion is not unusual compared to recorded crime data. According to the latest British Crime Survey (Chaplin et al., 2011), only about 49 percent of personal robberies are reported to the police. While slightly dated, the Commercial Victimisation Survey (Taylor, 2004) notes higher robbery reporting rates for business owners (78% for retailers and 57% for manufacturers).

Given this is one of the first analyses of maritime piracy in the criminological literature it seems there are a number of fruitful directions for future research:

1. *Regional analysis*. Partitioning this study region into smaller geographic areas in order to establish whether the space-time dynamics are stable or unstable at a local level. Research in crime hotspots reveals that many spatial concentrations are inherently unstable (Townsley et al., 2000; Weisburd et al., 2004). Very few studies examining near repeat patterns look at their spatial distribution within a study region. More impact could be gained by establishing whether particular areas are prone to near repeats. This may lead to more accurate predictions of communicability of risk.

2. *Trends in near repeats*. There was considerable contextual change in the region during this time period. It would be revealing to compare the space-time dynamics of piracy prior to the commencement of the joint EU and US naval operations. While evidence of displacement was observed, with a net reduction in pirate activity level, it remains an open question whether the near repeat patterns changed in the presence of increased patrolling. This is particularly important if patrolling is to be informed by the space-time thresholds of pirate risk communicability.

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