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Spatial decision making of terrorist target selection

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Student Declaration

I, Zoe Louise Marchment, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Date: 29th November, 2018

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This thesis is my own work and has not been submitted in the same form for the award of a higher degree at any other institution. Early versions of certain aspects of this thesis were published, or submitted for publication in the following periodicals:

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Abstract

Research consistently supports the notion that terrorists are rational actors. However, there has been a tendency to focus on distal factors associated with involvement in terrorism, and there is a distinct lack of empirical research on aspects of attack commission at the individual level. Little has been done to identify proximal factors associated with attacks. This thesis uses multiple paradigms from environmental criminology, including journey-to-crime analyses, various spatial and temporal statistics, risk terrain modelling and discrete choice modelling, to examine the target selection for two of the current national security threats to the UK: lone-actor terrorism and Northern Ireland related terrorism.

Collectively, the findings indicate that target selection is guided by an inherent logic, and that terrorists are rational in their spatial decision making. The first piece of analysis demonstrates that lone-actor terrorists behave in a similar way to group terrorists and urban criminals. Their residence-to-attack journeys display a classic distance decay pattern. The second empirical chapter shows how attacks by violent dissident Republicans in the period studied were spatially and temporally clustered. The following chapter identifies differences between risk factors for bombings and bomb hoaxes, and suggests that dissident Republicans may select less ideological targets for bombings relative to bomb hoaxes. The final empirical chapter demonstrates that the locations of attacks by the Provisional Irish Republican Army were influenced by characteristics of the target areas as well as the properties of their likely journey to the target.

In the concluding chapter, a new framework for target selection is presented and assessed using illustrative examples of recent attacks in the U.K. Important insights are provided that could guide and improve the efficacy of preventative and disruptive measures.

Impact Statement

From an academic perspective this thesis acts as a good foundation for future research, as it demonstrates that environmental criminological paradigms are useful in the study of terrorism. The findings add further support for the argument that terrorists act rationally when perpetrating an attack. All of the findings are likely to be adaptable to different contexts. The methods and results of this thesis have been disseminated across the academic community throughout the duration of the Ph.D. Several presentations have been given at academic conferences including the American Society of Criminology's and Society for Terrorism Research's annual meetings. Seminars and workshops have been given, or are planned, at UCL and other universities worldwide including Deakin University, Melbourne and Australia National University, Canberra. The remaining empirical chapters that are yet to be published are currently under review in leading journals.

As well has having an academic impact the important insights provided in this thesis have the potential to be utilised by practitioners and could enable intelligence services to make better informed decisions regarding counter-terrorism measures. The thesis provides empirical knowledge into terrorist attack strategies that can guide and improve the efficacy of methods to disrupt and prevent violent terrorist events. So far, the results have been disseminated to U.K., Norwegian and American security services, through both academic posters and presentations.

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Chapter 1   Introduction

On 16th June 2016, British Member of Parliament Helen Joanne 'Jo' Cox was fatally shot and stabbed multiple times in a targeted attack outside Birstall library in West Yorkshire, where she was due to hold an afternoon constituency surgery. The attacker, Thomas Mair, was a white supremacist who was fascinated with Norwegian extremist Anders Breivik. He had some ties to British nationalist and neo-Nazi groups, but seems to have been almost completely socially isolated. Just under a year later, on 2nd May 2017, Salman Abedi detonated an improvised explosive device (IED) packed with nuts and bolts in Manchester Arena's foyer. The attack took place after an Ariana Grande concert with over 14,000 people in attendance. 22 were killed. When taking into account psychological trauma and minor injuries, the estimated number of those injured is over 800. A few days later, the Islamic State of Iraq and Syria (ISIS) claimed the attack was carried out by a "soldier of the Khilafah". Though these attacks differed in sophistication, lethality, and motivation, the same questions arise from these events. Why did Abedi choose Manchester Arena, of all the potential targets in the city? Why was Jo Cox the subject of Mair's attack?

Simply: opportunity. Abedi was born in Manchester in 1994 and lived 4 miles away from the arena. Old Trafford, the home stadium of the premier league football club Manchester United, is also around 4 miles from Abedi's home address. Abedi decided against targeting Old Trafford due to situational security measures in place such as metal detectors (Intelligence and Security Committee of Parliament, 2018). At the time of Abedi's attack at the arena bag checks were no longer being conducted in the foyer. Mair lived just 1 mile away from the library where he attacked Cox. The library is easily accessible to the public and had no security measures in place. Mair had links to far-right extremism, including the National Front and English Defence League, and believed individuals who were liberal and left-wing were the cause of the world's problems. He targeted Cox as he believed her to be a 'passionate defender' of the European Union and a

"traitor" to white people. A witness stated that during the attack Mair shouted, "This is for Britain. Britain will always come first".

In the field of terrorism[1] studies there appears to be a distinct lack of empirical research on aspects of attack preparation and commission. There has been a recent increase in research regarding the prevention and interdiction of terrorist attacks, most likely due to the increase of frequency and lethality of attacks in Europe. However, this topic remains understudied, which is a critical oversight in this field. Many recent incidents, such as the 2017 attacks in London[2] and Manchester[3], have been highly publicised lone-actor terrorist attacks. This adds increasing pressure to policy makers and intelligence services from the public. Although there has been a noticeable increase in interest in the study of lone actors, in the field of terrorism research there has previously been a preoccupation with terrorist organisations as a whole. This approach has limited utility for the study of decision making regarding target selection at the individual level. Target selection research tends to focus on distal factors (i.e. the steps leading to an organisation to consider civilians as legitimate targets), rather than proximal causes. What has been done is largely anecdotal and yet to be empirically tested.

It can be argued that terrorists, be it group or lone actors, have an unlimited number of targets they could target. However, they do not all offer the same opportunity for attack. If terrorists are selecting targets in a rational manner, then the spatial patterns of attacks should be non-random. When examining group terrorist acts it is evident that, just like urban crimes, attacks do not occur randomly across time and place: they are spatially clustered (i.e. Berrebi and Lakdawalla, 2007; Townsley et al., 2008; Johnson and Braithwaite, 2009;

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[1] Terrorism is defined according to Gill et al.'s 2014 study: *"the use or threat of action where the use or threat is designed to influence the government or to intimidate the public or a section of the public and/or the use or threat is made for the purpose of advancing a political, religious or ideological cause. Terrorism can involve violence against a person, damage to property, endangering a person's life other than that of the person committing the action, creating a serious risk to the health or safety of the public or a section of the public, or facilitating any of the above actions."*
[2] Westminster, 22nd March, 2017
[3] Manchester Arena, 22nd May, 2017

Siebeneck et al., 2009; Medina et al., 2011; Behlendorf et al., 2012; Mohler, 2013; Tench et al, 2016).

Terrorist strategies are continuously changing in response to increased counter-terrorism capability. Rather than being high-level attacks on hard targets, contemporary attacks demonstrate a lower level of sophistication that can go undetected. Attacks tend to be of lower risk and on softer targets. From a rational perspective, soft targets may be value maximising due to the ease of operation and decreased risk of detection. Al-Qaeda used their publication 'Inspire' to promote simple attacks using common items for weapons (i.e. 'How to make a bomb in the kitchen of your mom') as opposed to traditional tactics. One issue in 2010 specifically encouraged the use of cars to run over individuals in public places. The use of easily obtainable weapons such as knives and vehicles are now common in attacks committed or inspired by ISIS.

Environmental criminology focuses on the *proximal* determinants of crime, i.e. the situational aspects of the crime event, as opposed to the *distal* causes that shape the offender's disposition towards crime (Wortley and Townsley, 2016). Proximal causes are easier to alter, for example through the use of situational crime prevention (SCP) techniques, and have the most direct influence on behaviour (Wortley and Mazzerole, 2016). This means crime reduction effects can be produced relatively quickly. There is a growing literature that suggests environmental criminology is applicable to terrorism (Cothren et al., 2008; Townsley et al., 2008; Legault & Hendrickson, 2009; Wilson et al., 2010; Rossmo & Harries, 2011; Gruenewald et al., 2015; Braithwaite & Johnson, 2015; Tench et al., 2016; Gill, Horgan and Corner, 2017). Empirical research examining the efficacy of this approach is a developing area. Studies cover a wide range of subjects, such as victimology (Wilson et al., 2010), attack characteristics such as target and weapon choice (Gruenewald et al., 2015; Legault & Hendrickson, 2009), spatial and temporal characteristics such as clustering (Townsley et al., 2008; Rossmo & Harries, 2011; Braithwaite & Johnson, 2015; Tench et al., 2016), journey to attack distances (Cothren et al., 2008; Gill, Horgan and Corner, 2017) and displacement (Hsu & Apel, 2015). Clarke and Newman's (2006) 'Outsmarting

the Terrorists' applies methods from environmental criminology to terrorism, however they acknowledge that, due to a lack of empirical data, the way in which they do so is largely anecdotal. Successful empirical application of these paradigms could be extremely useful for the prevention and interdiction of terrorist acts.

Characterised mostly by the identification of spatial patterns, this thesis uses paradigms from environmental criminology to examine the target selection for two of the main current national security threats to the United Kingdom (U.K.): the threat from Northern Ireland related terrorism and the threat from lone-actor terrorism. The thesis expands on the little research that exists, using detailed data sets where it is evident that factors of target selection were dependent on the decision making of the individual who implemented the attack. Micro-level (individual-level) analyses will be employed to examine the behaviour of individuals to better understand the proximal (rather than distal) decision making surrounding a terrorist attack.

An exploration of the spatial decision making of terrorists provides important insights into terrorist attack strategies, thus providing knowledge to guide and improve the efficacy of methods to counter violent acts of terrorism. This empirical knowledge will enable intelligence services to make better informed decisions regarding preventive and disruptive measures.

Three datasets are used in this thesis. The first contains all lone-actor terrorists attacks that fit the specified inclusion criteria[4] spanning the period January 1990 to July 2016. The second contains violent dissident Republican (hereafter, VDR) incidents committed in Northern Ireland between January 2007 and December 2016. The third consists of attacks committed by core active members of the Provisional Irish Republican Army (hereafter, PIRA) in Belfast, from 1969-89, where both the attack location and an accurate home location of the offender could be identified.

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[4] This will be fully discussed in the methods section of the associated chapter.

1.2 Chapter outline

This thesis contains seven chapters. Chapter 2 presents the thesis' theoretical basis and provides guidance for the subsequent chapters. Spatial research from environmental criminology and their relevant application to terrorist events, as well as the existing literature regarding terrorist threats, are discussed. This section exposes the gaps in literature surrounding this topic, highlights limitations of existing studies, and provides a suitable knowledge base for the subsequent analyses.

Chapter 3 analyses the residence-to-attack distances of lone-actor terrorists in Western Europe and the United States (U.S), under the assumption that the decision-making processes of these actors are like those of urban criminals when selecting suitable targets. Distance decay patterns that have been found for urban crimes and group terrorism are reflected in the results. The findings demonstrate that the application of environmental criminology is appropriate and beneficial in the study of lone actors, providing a starting point for further environmental criminological analyses of lone-actor attacks beyond this thesis.

Chapter 4 builds upon this line of argument by analysing the spatial and temporal characteristics of a campaign of violence (as opposed to the sporadic individual attacks characterised by lone-actor terrorists). In particular, it focuses on contemporary VDR activity from 2007 to 2016. The results demonstrate that, like urban crimes, VDR incidents were spatially and temporally clustered during the period studied.

Chapter 5 extends on chapter 4 by applying risk terrain modelling to VDR bombings and bomb hoaxes in the city of Belfast to identify physical and social features of the environment that are correlated with hotspots of activity. The models identify specific areas that may be more vulnerable to VDR incidents than elsewhere in the city and should therefore be prioritised in security measures. The results suggest that terrorist offenders assess risk and select targets

rationally. They may seek less ideological but more realistic targets for bombings relative to bomb hoaxes.

To overcome limitations of target based or offender based studies in previous research, as well as the preceding chapters of the thesis, chapter 6 applies discrete choice modelling to PIRA attacks in Belfast. This method allows distance to be treated as an explanatory variable and for several other choice criteria to be examined. As well as considering areas of a city that were chosen for an attack, it simultaneously examines those that were not. The results suggest that areas that are closer to the offender's home, more accessible, and contain entities that can be considered symbols of ideology are more likely to be targeted.

The final chapter, 7, summarises the findings of these analyses and discusses the practical implications. A new framework for target selection is presented and assessed using illustrative examples of recent attacks in the U.K. Guidance for policy makers and potential future avenues for research are considered.

Chapter 2   Literature Review

2.1   Introduction

This chapter begins with an overview of the general themes of research in the field of terrorism studies, with a specific focus on studies relevant to terrorist target selection. Environmental criminological paradigms and quantitative analyses will be applied throughout this thesis and will be discussed in the subsequent sections. The three overarching theories which provide the theoretical foundations for this work are a) the *rational choice perspective* (Cornish and Clarke, 1986), b) *routine activities theory* (Cohen and Felson, 1979) and c) *crime pattern theory* (Brantingham and Brantingham, 1981). These paradigms have been widely researched when considering urban crimes such as burglary, but their usefulness for explaining patterns in terrorism remains understudied. Then I provide an overview of the two threats to U.K. national security that are primarily analysed in this thesis: lone actor terrorism and Irish Republican-related terrorism.

2.2   Background

The overwhelming focus of most studies within the field of terrorism studies has been to identify distal rather than proximal causes, with the aim of explaining the *'terrorist'*, rather than the *'terrorist act'*. Terrorism studies emerged in the early 1970s within the fields of history, political science and sociology, with the aim of explaining the emergence of politically violent campaigns within their socio-political context. Many of the first analyses of terrorism aimed to identify dispositional traits of terrorist group members. These approaches emphasised psychopathy and other personality traits, claiming terrorists to be 'irrational' actors (Morf, 1970; Hassell, 1977; Pearce, 1977; Cooper, 1978).

Scholars then attempted to determine the aetiology of terrorism, with the aim of identifying 'root causes' of terrorist grievances (Jenkins, 1974; Hyams 1975; Wilkinson, 1977; Cooper, 1978). Individual and group agency in decision-making was emphasised in these approaches. These studies sought to identify the conditions of a social environment, such as poverty and social inequality, that could result in the emergence of terrorist groups. This kind of approach is problematic, as these 'causes' can produce many different kinds of social outcomes and have both positive and negative effects (Bjorgo, 2005), and the majority of individuals in the same settings will not turn to terrorism. Further, this approach ignores any immediate circumstances of events that amplify support for the cause or provoke the terrorist act.

After the September 11th 2001 attacks on the World Trade Centre and the Pentagon (hereafter, 9/11) there was a dramatic increase in terrorism research. Analyses tended to focus on understanding the ideology of terrorists and processes of radicalisation, counter radicalisation and de-radicalisation (Wiktorowicz, 2005; Dalgaard-Nielsen, 2010; Moskalenko and McCauley, 2011; Bouhana and Wikstrom, 2011; Richards, 2011; Jones, 2014). Desmarais et al's (2017) systematic review of the scientific knowledge regarding risk factors for terrorist involvement found that terrorism was treated largely as a homogenous construct, and that the existing literature has mainly focused on distal explanations, such as factors associated with socio-demographic characteristics, criminal history, religiosity and mental health. Studies examining the association between proximal factors, such as personal experiences, and terrorist engagement were depicted as 'rare' and 'infrequently examined' (Desmarais et al. 2017: p. 190).

No consistent 'terrorist profile' has been found (Horgan and Taylor, 1997) and descriptive indicators are unstable over time and geography (Horgan et al., 2016). Even if one could be found, the utility a profile could offer is limited. Certainly, there are several process variables which need to be considered and should not be overlooked. However, risk factors for involvement in terrorism cannot explain differences between two individuals with the same 'risk factors',

where only one of them will be recruited into a terrorist organisation, or commit an attack.

To date, most approaches have focused on the radicalisation and recruitment process as opposed to the attack commission process. Little has been done to explore the reasons why a terrorist act was committed at a specific place and time. Why are some targets more vulnerable than others and how are they chosen? There have been very few attempts to develop specific models that give a better understanding of why targets are selected by terrorists. Most notable is Clarke and Newman's 'EVIL DONE'. This model is based on situational crime prevention (SCP), examining the situational characteristics that allow the perpetrator to successfully complete an attack. Clarke and Newman propose that targets that are *exposed, vital, iconic, legitimate, destructible, occupied, near* and *easy* are considered to be more at risk.[5] The application of SCP measures to terrorism was introduced in Clarke and Newman's 2006 book entitled 'Outsmarting the Terrorists'. A limitation of this work is that much of it is anecdotal and not guided by empirical evidence. In a recent review of published works pertaining to situational crime prevention and terrorism, Frielich et al. (2018) also found that less than half of the sample were based on empirical observation, and only 28% used a quantitative approach.

It can be argued that one of the most effective ways of preventing terrorism is to disrupt the opportunity structure. All types of terrorist attack depend on a combination of multiple opportunities. In turn, each specific attack type offers its own set of environmental opportunities that can be manipulated with the intention of impacting the offender's cost–benefit calculus and disrupting the terrorist act. For events such as criminal damage acts committed by domestic extremists, the effects of situational crime prevention measures may be less of a deterrent. This may be because this is a low risk event, and the individuals involved believe that the rewards outweigh the risk. A recent analysis demonstrated that the presence

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[5] EVIL DONE is an adaptation of the acronym CRAVED (Clarke, 1999) - *concealable, removable, available, valuable, enjoyable* and *disposable* - that is used to assess the attractiveness and suitability of targets of urban crime.

of lighting and CCTV did not deter domestic extremists from committing criminal damage (Robinson, Marchment and Gill, 2018). It is also possible that the target selected was one of many targets, and that the one selected was the one perceived as the least risky (or most convenient). How offenders perceive the effectiveness of proximal security measures is important. Criminological studies generally highlight that offenders' perceptions of how security is deployed as opposed to solely their presence is what matters in their risk calculus (i.e. Taylor and Nee, 1988; Butler, 2005; Nee and Meenagham, 2006; Bernasco and Jacques, 2015).

The focus on terrorism as a political, rather than criminal, problem has led to a tendency of explaining the terrorist attack in terms of a group's ideological position (Drake, 1998) or strategic orientation (Abrahms, 2008). Whilst the rationality of the adoption of terrorism as a strategy or tactic has been considered, the rationality underpinning actual attack commission is yet to be studied extensively. The lack of empirical research into proximal factors of target selection is a critical oversight in this field. Studies on the subject have been largely anecdotal or descriptive in nature (see Clarke and Newman, 2006). However, these studies taken in combination with the paucity of empirical research has led to the consensus that terrorist target selection is not indiscriminate and follows contextual logic (de la Calle and Sánchez-Cuenca, 2006; Asal et al., 2009; Røislien and Røislien, 2010). This contextual logic can be defined by factors such as ideology, proximity, capability, accessibility, and feasibility.

Ideology, defined by Drake (1998: 2-3) as *"beliefs, values, principles, and objectives – however ill-defined or tenuous - by which a group defines its distinctive political identity and aims… and provides a motive and framework for action",* has been a prevalent focus in target selection studies. A group's ideology is important when considering target selection as it provides a framework by identifying the 'enemies' and legitimate targets of the group. For example, Gruenewald et al. (2015) found that eco-terrorists in the U.S. most commonly selected targets that could be considered as legitimate, i.e. commercial

businesses or individuals they considered to be responsible for causing harm to the environment. However, as Drake (1998) highlights, ideology is not the sole determinant of whether a potential target is attacked. While ideological beliefs play a fundamental role in targeting behaviour, they are difficult to test empirically and research should not be restricted by solely considering these factors (Crenshaw, 1981; 1988).

Proximity to the target has been considered a key feature of terrorist target selection (Clarke and Newman, 2006). Terrorists are limited by the same geographical constraints as urban criminals and tend to keep the distance travelled from their home to the target minimal to increase the utility of their attack. LaFree, Yang and Crenshaw (2009) found that most domestic anti-U.S. attacks between 1970-2004 involved local targets which were close to the terrorist's home. Cothren et al. (2008) found around half of group attacks in the US took place within 30 miles of the home location. Gill et al. (2017) found that nearly two thirds of PIRA members travelled less than 4 miles to commit their attacks. 40% of all attacks occurred within 1 mile of the offender's home location. Eby (2012) found that many of the 53 lone actors in his analysis stayed within their home towns to commit their attacks.

Target selection can also be affected by capability. Damphousse et al. (2002) examined actual and intended targets of terrorist attacks in the United States (U.S.) between 1980 and 1998. They found that although 57% intended to target government or military buildings or personnel, only under 20% of the attacks actually hit these types of targets. Transnational terrorists have changed their target choices in response to target hardening (Brandt and Sandler, 2010). Success in preventing attacks against officials and military has motivated terrorists to change their tactics, with an increasing preference towards softer targets. Brandt and Sandler (2010) found an increasing tendency to target people over property since the 1990s. Asal et al. (2009) looked at the factors leading to terrorist group's decision to turn to softer targets such as civilians, tourists or the media. They found that groups with a religious ideology were more likely to attack soft targets than other types of groups. Røislien and Røislien (2010) found that

attacks carried out by Palestinians within Israel tended to occur in significant but poorly guarded public places, such as shopping malls.

Target accessibility and feasibility may be other crucial components of target selection. Berman and Laitin (2008, p. 144) highlight the importance of accessibility in the target selection process: *"Settlers and soldiers use roads that pass through heavily populated areas or through terrain that is easily attacked. . . . The result is that an attacker can fire a weapon or detonate a bomb remotely in such a way that makes escape relatively easy afterwards. . . . In contrast, targets on the Israeli side of the 'green' line are much 'harder', posing much greater risks for the attacker."* Ozer and Akbas (2011) suggest the reason one of the major police stations in Istanbul is targeted by terrorists is because this station is connected by major streets. Using Clarke and Neman's EVIL DONE framework, they found that all of the buildings targeted by the Partiya Karekeren Kurdistan (PKK) during the period studied were easily accessible. Using the same framework, Gruenewald et al. (2015) found a preference for 'accessible' and 'easy' targets for eco-terrorists in the U.S.

Research activity surrounding terrorism in the field of criminology has increased in recent years. There have been major advances in a variety of areas, although there are still notable gaps in the literature. Although the field of terrorism is becoming increasingly more empirically oriented, a major problem that remains is a distinct lack of reliable and detailed data due to the clandestine nature of the subject. In his review of data and methods utilised in terrorism research Schuurman (2018) found that the use of primary data has increased considerably since the early 2000s and continues to do so. However, over 78% of the articles studied did not use any kind of statistical analyses. Another main limitation of previous studies is the tendency to treat different types of terrorist incident as homogeneous in nature. Differences in attack types are also rarely considered. Likewise, terrorist actors are treated as monolithic, and studies consistently fail to effectively distinguish between different member types, both across groups and within them.

Terrorism research increasingly covers issues such as target choice, weapon choice, the spatio-temporal clustering of terrorist attacks, the distances travelled to commit a terrorist attack, victimology, and the displacement of incidents (Cothren et al., 2008; Townsley et al., 2008; Legault & Hendrickson, 2009; Wilson et al., 2010; Rossmo & Harries, 2011; Gruenewald et al., 2015; Braithwaite & Johnson, 2015; Tench et al., 2016; Gill, Horgan and Corner, 2017). These findings show great promise and reinforce the argument that when we focus on terrorism from a preventative angle, we should focus on terrorist behaviours – *what they do* – rather than remain preoccupied with concerns about *who they are* or *why they have become terrorists*. Distal approaches have limited utility in the prevention of terrorist acts, however proximal factors of the immediate environment shaping decision making regarding target selection are yet to be examined fully.

2.3 Theory

Traditional criminology seeks to identify and explain *why* individuals engage in criminal activity, with a focus on sociological, psychological and developmental perspectives. There is a focus on criminality and the criminal disposition, and the factors underlying why an individual would engage in crime. However, this emphasis on the distal causes of crime offers little insight to the proximal determinants of criminal activity, such as why a particular target is chosen (Brantingham and Brantingham, 1981; Clarke, 2004). To address these limitations an alternative framework, *environmental criminology,* was introduced (Brantingham and Brantingham, 1981). Environmental criminology emphasises the importance of the crime setting and the role of person-situation interactions. It posits situational factors and the environment as key in determining spatial and temporal distributions of crime. Environmental criminology is focused on *where, when* and *how* crime events occur, as opposed to *why* they occur.

The following section discusses the three main perspectives within environmental criminology: the rational choice perspective (Cornish and Clarke, 1986); routine activities theory (Cohen and Felson, 1979) and crime pattern theory (Brantingham and Brantingham, 1981). These theories influence the understanding of 'crime and place', are mutually compatible, and provide the theoretical foundations for this thesis.

2.3.1 Rational choice perspective

The modern rational choice perspective of crime, as proposed by Cornish and Clarke in 1986[6], assumes that offenders are rational and purposeful in their decision making. The perspective denotes that an offender acts in their own self-interest while calculating the costs and benefits of each possible alternative, before making a choice that offers the greatest benefit and lowest cost (Cornish and Clarke, 1986). This decision-making process can then be subdivided into: a) decisions regarding criminal *involvement*, and b) decisions regarding criminal *events*. As mentioned previously, most terrorism research focuses on involvement. This thesis focuses on the latter process: the proximal decision making that defines the criminal event, in this case a terrorist attack.

When a rational actor makes a choice, there is the assumption that they will be utility maximising (making a decision that offers the best perceived utility) based on expected rewards, effort and risk (Phillips, 2011; Phillips and Pohl, 2012). Rationality is subject to limits and is guided by time, effort, experience and knowledge (Clarke and Felson, 1993; Beauregard et al., 2005). This led Cornish and Clarke[7] to posit that offenders act with *bounded rationality*. This concept, relating to the criminal event, posits that crime is influenced by opportunities, and

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[6] This work stemmed from economist Gary Becker's 1968 paper, in which he argued that choices regarding crime are not dissimilar to other non-crime related decisions. Cornish and Clarke's model differs from Becker's economic model as it emphasises that utility is not always dictated by monetary gain.

[7] As well as Simon, 1957;1986.

that the opportunities are dependent on the individual's environment. Although their knowledge of the associated effort, rewards and risks is imperfect, an offender will still maximise utility based on what they do know.

2.3.2 Routine activities theory

Cohen and Felson (1979) introduced routine activities theory to describe the circumstances in which crimes occur. The perspective extends the concept of bounded rationality into the physical world and expresses that crime occurs when a motivated offender, a suitable target and a lack of a capable guardian, come together in time and space. Capable guardians include the police and other security professionals (formal guardians), but also extend to ordinary citizens (informal guardians) and implied guardianship e.g. systems such as closed circuit television (CCTV) cameras and burglar alarms. Cohen and Felson propose that these three factors come together naturally, as individuals go about their daily routines.

Since its introduction, there have been many extensions upon routine activities theory (including but not limited to: Felson, 1986; Eck, 1994; Felson and Clarke, 1998; Sutton, 1998; Sampson et al., 2010), and it has been applied extensively alongside the rational choice perspective in the study of urban crimes including burglary (e.g. Wright and Decker, 1994), and shoplifting (e.g. Schlueter et al., 1989). From the early 1990s the perspectives began to be successfully applied to other volume crimes such as drug dealing (e.g. Jacobs, 1996), white-collar crime (e.g. Paternoster and Simpson, 1993; Simpson et al., 1998), gang membership and violence (e.g. Spano et al., 2008), organised crime (e.g. Kleemans, 2012), and carjacking (Jacobs et al., 2003). Further, it has been applied to non-acquisitive offences such as sex offending (e.g. Beauregard & Leclerc, 2007; Deslauriers-Varin and Beauregard, 2010) and violent offences (Topalli, 2005), with the consensus that offenders 'read' their immediate environment to guide their decisions in the commission of their offence.

2.3.3 Crime pattern theory

Brantingham and Brantingham (1981) extended upon rational choice and routine activities theories to understand crime events with a spatio-temporal approach. As an individual navigates their city or town on their journeys to and from their daily activity nodes (including places such as their home, places of work and/or education, and leisure and recreation venues) they will become more familiar with certain areas than others. Over time, their increased knowledge and familiarity with these areas means they become part of an individual's *awareness space*. Offences will occur when this awareness space overlaps with an opportunity for criminal activity. This leads to clear and consistent patterns in which individuals commit crime in areas that are known to them (such as White and Clyde, 1932; Harling 1972; Georges-Abeyie & Harries, 1980; Rhodes and Conley, 1991; Warren et al., 1998; Barker, 2000; Rossmo, 2000; Costello and Wiles, 2001; Lundrigan and Canter, 2001; Laukkanen and Santtila, 2006; Santtila, Laukkanen and Zappalà, 2007; Bernasco and Block, 2009). To travel further beyond their awareness space to commit an offence would mean increased time and effort for the offender, as well as an increased level of perceived risk due to their unfamiliarity with the area. Offending in areas they are familiar with reduces the individual's risk of detection and interception.

Crime pattern theory also highlights the *environmental backcloth,* i.e. elements of the physical environment which guide an offender's spatial decision making and facilitate crime distribution. The physical infrastructure of the environmental backcloth, and the influence this may have on an individual's awareness space, needs to be considered when examining terrorist target selection. Crimes within an offender's awareness space are not equally distributed. This is due to variances in the presence and concentration of suitable targets, which add bias to an individual's awareness space (Brantingham and Brantingham, 1995). These may include places known as *crime generators,* which attract large numbers of individuals for reasons that aren't related to crime (i.e. shopping centres), and *crime attractors,* which specifically attract criminals (i.e. drug markets) (Brantingham and Brantingham, 1995). Areas that do not attract large

numbers of individuals, in any respect, are known as *crime neutral* areas. The environmental backcloth also varies across time, and some locations may only be suitable targets at certain times of day, or certain days of the week. For example, shopping centres attract large crowds, but tend to only do so during the day, whereas the converse is true for bars and nightclubs (Eck and Weisburd, 2015).

There is widespread research based on these theories regarding spatial, temporal, and spatio-temporal patterns for traditional urban crimes, which has had important implications for policing and crime prevention (Johnson et al., 1997; Bowers et al., 1998; Ratcliffe and McCullagh, 1998a, 1998b; Ratcliffe, 2000, 2002, 2004; Townsley et al., 2000; Townsley and Pease, 2002; Townsley et al., 2003; Bowers et al., 2004; Johnson and Bowers, 2004a, 2004b; Bowers and Johnson, 2005; Ratcliffe, 2005; Johnson et al., 2007; Johnson, 2008; Ratcliffe and Rengert, 2008). The literature consistently demonstrates that crime is spatially concentrated. Urban crimes, such as burglary and robbery, occur most often near common routine activity nodes (Bowers, 2014) and in places that would be known to a large number of people (Johnson and Bowers, 2010; Davies and Johnson, 2015), for example the roads most travelled on in a city. There is also a substantial literature regarding spatial patterns for violent crimes. For example, the spatial behaviour of serial killers shows logic in spite of the motives being guided by emotion (Lundringan and Canter, 2011) and similar spatio-temporal patterns have been found for shootings (Ratcliffe and Rengert, 2008). Much of the contemporary criminological research focuses on identifying patterns at the local level, with micro-level (individual-level) analyses being at the forefront of emerging research (Weisburd, 2015).

2.3.4 Applications to terrorism

Treating the terrorist as a rational actor is not a new approach. Although the goals of a terrorist may be irrational, their actions will be guided by rationality. The rational choice perspective has been useful in understanding political violence including terrorism (Pape, 2005; Clarke and Newman 2006) and literature

consistently supports the presumption that terrorists are rational actors (Sandler et al, 1983; Enders et al., 1990; Enders and Sandler, 1999; Crenshaw, 2000; Silke, 2001; Pape, 2005; Taylor and Horgan, 2006; Caplan, 2006). Committing an act of terrorism, whether under the guidance of a wider network or as a lone attacker, is a purposeful behaviour that is guided by rationality. Although the 'best' choice may not be taken, a deliberative process of thinking will have been engaged with.

Terrorists make carefully calculated choices that are value-maximising (Asal et al., 2009) with the intention of increasing their probability of success (Hoffman, 2006). There is evidence to suggest that there is a calculation of perceived risks in the selection of targets at the group and individual level (Mickolus, 1980; Sandler et al., 1983; Sandler and Lapan, 1988). Airline hijackings and chemical, biological, radiological and nuclear (CBRN) incidents, which are associated with high risk, are among the lowest level occurrences amongst terrorist activities, whilst low risk incidents such as bombings and shootings are amongst the highest (Sandler et al., 1983; National Consortium for the Study of Terrorism and Responses to Terrorism, 2016). This implies that there is some consideration of risk by the offenders. Dugan et al. (2005) used a rational choice model to analyse the rewards, risks and costs associated with airline hijackings. They found that hijacking frequencies decreased after the installation of metal detectors and an increased presence of law enforcement in airport checkpoints, due to the increased risk of detection. When applying the rational choice perspective to terrorist incidents in Israel, Brophy-Baermann and Conybeare (1994) found that initial Israeli retaliations against terrorism led the terrorists to change their strategies as they expected further retaliations.

Considerations of issues like security, avoiding detection, and ease of access and escape are regularly engaged upon. Jenkins (1985) observed that terrorists spent a lot of time deliberating over targets and deciding which were the most vulnerable. This cost-benefit consideration was demonstrated in a recent analysis of terrorist autobiographies providing further support for the rationality of terrorists (Gill et al., 2018). One finding particularly relevant to this thesis was that "terrorists

often keep several potential targets in mind and choose the one with relatively fewest risks" (p. 5). The factors considered encompassed both subjective and objective factors and, in many ways, mirrored criminological findings related to criminal cost–benefit decision making. There were many depictions of how fear and nerves negatively impacted the decision-making processes in planning and carrying out an attack, which were reflective of findings from studies of urban criminals including street robbers, shoplifters, and burglars. These appeared to be most intense during the commission of an attack. Another prominent finding was the consideration of situational security features. They found the offender's evaluation of security features at the target necessitates hostile reconnaissance. This awareness of security factors often led to doubts and irregular behaviour at the target, increasing the risk of the terrorist being detected. Consistent with findings from studies of urban crime (Taylor and Nee, 1988; Butler, 2005; Nee and Meenagham, 2006; Bernasco and Jacques, 2015), perceptions of how effectively deployed security was important in this process.

Spatial analyses in the field of terrorism research do not fully reflect the advances made in the study of general crime. This thesis attempts to bridge that gap. Like urban crimes, terrorist attacks do not occur randomly in time and space. Both criminals and terrorists are subject to geographical constraints and other limitations associated with access to resources. Although the ideological underpinnings of their actions may be irrational, a terrorist's decision-making process will follow some form of logic, and the locations they choose to attack will not be arbitrary. Therefore, analyses of this kind can inform strategies by identifying areas that may benefit from disruptive and preventive measures, such as SCP.

The first applications of spatial analyses to examine the distribution of urban crimes were mostly concerned with identifying patterns at the macro level, e.g. at state or nation level. This has been true too for the study of terrorism. For example, studies have analysed whether there is a contagious diffusion like element of terrorism (Midlarsky et al., 1980; LaFree, 2018), the transnational displacement of terrorism following 9/11 (Enders and Sandler, 2006), and the

clustering of attacks cross-nationally (Midlarsky et al., 1980; Braithwaite & Li, 2007; LaFree et al., 2012). The main limitation of studies at the macro level is that they assume that all space within each delimited geographic area is equally likely to experience the same amount of terrorism risk. This means the impacts of these attacks at a finer aggregation cannot be estimated. Whilst the results of macro-level studies have limited practical use, their findings of spatial clustering at the country level provide a great starting point for further spatial analyses at finer spatial resolutions within these countries (Li, 2005; Piazza, 2008).

Most research on the spatial patterns of terrorism has focused on meso-level analyses. Meso-level analyses are concerned with examining the space in between macro-level (national or international) and micro-level (individual) factors, and typically focus on sub-national regions and communities. In an analysis of group attacks in Israel, Berrebi & Lakdawalla (2007) found four key determinants of risk variation according to space, the most useful being that of proximity of terrorist operational bases. Similarly, Rossmo and Harries (2011) found that terrorist cell sites were clustered and found evidence for distance decay in a study of organisations in Turkey.

Most geospatial research is guided by the least effort principle (Zipf, 1965) which expresses that when considering a *"number of identical alternatives for action, an offender selects the one closest to him in order to minimize the effort involved"* (Lundrigan and Czarnomski, 2006, p.220). When considering urban crimes an offender's journey to their crime location typically demonstrates a distance decay function, where the frequency of offences decreases as the distance from the home increases. Proximity to a terrorist's home location has shown potential to be a useful predictor of where an attack may take place for group-based terrorism. Cothren et al., (2008) found that just under half of group-based attacks occurred within 30 miles of the offender's home location, while Clarke and Newman (2006) argue that "proximity to the target is the most important target

characteristic to terrorists" (p.154).[8] However, within these studies, there have been very few attempts to disaggregate the data, meaning that all types of attacks are treated as a homogenous construct.

There is also a crucial temporal element to criminal activity. Whilst it has been long noted that victimisation increases the probability of future victimisation (Farrell, 1995; Pease, 1998), spatial and temporal analysis has provided the means to model the subsequent variations in risk. With regard to residential burglary, research shows that following one offense there is a temporary elevation in risk of further offenses at the same home and those nearby (Townsley et al. 2003; Johnson and Bowers, 2004a). In other words, the risk of burglary displays a contagious quality in terms of its space-time distribution. Further research shows such variations in risk are largely ubiquitous, with similar patterns observed across different areas and within different countries (Johnson et al., 2007). For example, the risk of victimisation is similarly contagious in relation to motor vehicle theft (Lockwood, 2012), shootings (Ratcliffe and Rengert, 2008), assaults and robberies (Grubesic and Mack, 2008), and maritime piracy (Marchione & Johnson, 2013). In each case, an elevation in risk extends beyond the location of the original incident and then decays over time.

Like urban crime, these temporal variations are also evident in attack patterns in sustained conflicts. Hotspots of violence during violent campaigns have been identified and spatio-temporal trends of terrorism decay in similar manner to traditional crimes. Townsley et al. (2008) used the Knox (1964) test to analyse IED attacks by insurgents in Iraq. Attacks were non-random and were clustered in space and time. After an initial attack, a further attack was likely within 1km and within two days. Braithwaite and Johnson (2012) found similar results in their analysis of insurgent attacks alongside counter-insurgency operations. Insurgent attacks clustered, and there was an immediate increase in risk in the immediate vicinity of the attack, which sharply decreased after. Berrebi and Lakdawalla

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[8] A more detailed discussion of the distance decay function and analyses will be presented in chapter 3.

(2007) found that the risk of subsequent related incidents rose after an initial attack in Israel before returning to the baseline after approximately eight weeks. Similarly, Marchione and Johnson (2013) found that following an initial incident of maritime piracy, the risk of a subsequent incident increased temporarily. Behlendorf et al. (2012) found spatio-temporal clustering in attacks by Euskadi Ta Askatasuna (ETA) in Spain and the Farabundo Marti National Liberation Front (FMLN) in El Salvador. Terrorist attacks are not randomly distributed and factors such as the location of the attack and the time passed since the previous incident have been shown to help determine the location of future attacks (LaFree et al., 2012). Braithwaite and Johnson (2015) conclude that risk heterogeneity is an especially important factor when understanding spatial-temporal patterns of IED attacks.

Local infrastructure is another important element to consider as variations offer different opportunities, risks and rewards. However, a consideration of how the environmental backcloth of a city shapes the behaviour of terrorists has largely been neglected. Zhukov (2012) demonstrated the importance of road networks in a study of insurgent activity in North Caucasus and concluded that they were the most important determining factor for the location of attacks. Johnson and Braithwaite (2009) postulate that attacks by violent actors such as insurgents are concentrated in certain areas for tactical reasons, in an attempt to exhaust the resources of the opposition. The identifications of patterns such as these have implications for predicting where group attacks are likely to occur in future. However, these studies neglect to explore how targeted locations differ from one another, i.e. why one location is chosen from a number of very similar discrete alternatives. Another weakness of these studies is that they assume underlying processes that determine the locations of the attacks are homogenous and there is no consideration of ideological factors that may shape targeting behaviours.

2.4 Lone-actor terrorism

The first analysis of this thesis focuses on lone-actor terrorism. Whilst the promotion of lone attacks by larger organisations is not a new threat – the use of lone attacks was encouraged by both right-wing extremists in the early 1990s and al-Qaeda in their publication 'Inspire' during the 2000s - recent high profile incidences of lone actor terrorism have attracted interest from policy makers and heightened national security concerns. Studies suggest that lone attacks have increased in frequency (Coffey, 2011; Eby, 2012; Nesser, 2012; Feldman, 2013; Appleton, 2014) and lethality, with the number of injuries and fatalities per attack rising considerably post 9/11 (Teich, 2013). The following quotation, from ISIS' publication 'Dabiq' is an example of how terrorist organisations have continued to promote the use of lone actor attacks as part of their strategies (Ellis et al., 2016). *'The smaller the numbers of those involved and the less the discussion beforehand, the more likely it will be carried out without problems... One should not complicate the attacks by involving other parties, purchasing complex materials, or communicating with weak-hearted individuals"* (Dabiq, The Failed Crusade, p. 44).

Lone actors pose several challenges for law enforcement, and given the recent substantial increase in the number and diversity of lone actor attacks it is important to establish patterns related to target selection to aid prevention and investigation efforts. Previously, this sub-field has been dominated by descriptive studies which have limited external validity, and there is a clear need for exploratory analyses. There has been little empirical research guided by the application of environmental criminological paradigms specifically for lone actor terrorism. Spatial patterns that we see for group terrorism and insurgency such as clustering and hotspots are unlikely to be replicated for lone attacks. This lack of a pattern means they are harder to predict or prevent. Risk forecasting used for group terrorism may not be appropriate.

Although it is not a new phenomenon, at present there is no commonly accepted definition of lone-actor terrorism, and there is a lack of consensus regarding

terminology (Spaaij, 2010; Borum et al., 2012; Borum, 2013; Appleton, 2014; Spaaij and Hamm, 2015). Debates usually centre on whether the actor operates with or without the assistance of others. Lone actors may not be part of, or actively supported by, extremist movements (Pantucci, 2011; Nesser, 2012). However, there is a consensus that these individuals are not all that 'alone'. Most are not completely socially isolated, with many cases interacting with other extremists and wider networks either face to face or online (Gill, 2015). Generally, a lone-actor attack is considered by most scholars to be an attack by an individual who is not *directly instructed* to commit the attack by a group (but may have minor connections to, or be inspired by, a wider network) (Phillips, 2015)[9].

Traditionally, research on lone actors has focused on behavioural indicators. It is accepted that there is no utility to a lone actor 'profile', however there are a few characteristics that distinguish them from group terrorists (Gruenewald et al. 2013; Gill et al., 2014). Lone actors tend to be older than group actors, which is also typical of urban criminals, and tend to follow a different temporal trajectory (Gill et al., 2014).

The solitary nature of some individuals does increase the difficulty of surveillance and reduces the efficacy of most traditional intelligence techniques (Brynielsson, 2013). However, lone actors are not completely undetectable. A notable characteristic of lone actors is leakage behaviour. It was originally assumed that one prominent factor making interception so difficult was that lone actors tended not to communicate with others. However, they often reach out to others for guidance and support and disclose details of their violent intents in advance to a third party via social media or in person (Meloy et al., 2012; Gill, 2015). This communication may, in their perception, increase their potential to be more successful. However, this leakage behaviour also increases the lone actor's vulnerability by leaving them susceptible to detection, and can therefore aid disruption efforts. Gill (2015) found that in 79% of the cases in the sample used,

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[9] For clarity, the specific inclusion criteria for the lone actor analyses of this thesis is outlined in chapter 3.

other people were aware of the extremist's ideology. In 64% of cases the individual had verbally told a family member or friend of their intent to engage in terrorism related activities. Almost half of the individuals had interacted with other extremists face to face. Gill (2015) found that there is often a meaningful and personal connection to the attack context. For example, when selecting a church to target, right wing extremist Jim Adkisson chose the one attended by one of his ex-wives. This information, coupled with the knowledge that lone actors often leak details regarding the specifics of their upcoming attacks, offers an opportunity for disruption.

Lone actor attacks are of lower lethality than group attacks, tend to be simple and straightforward, and typically lack the sophistication of group attacks (Bakker and de Graaf, 2010; Jasparro, 2010; Barnes, 2012; Ackerman and Pinson, 2014; Appleton, 2014). This is likely due to a lack of support from others and the resources of a wider organisation. As they are less likely to have the knowledge and expertise to construct an explosive device (Kenney, 2010; Ackerman & Pinson 2014), and lack the resources that members of a wider organisation benefit from, the weapons and methods used are often low level. An individual that is often at the forefront of discussions surrounding lone actor terrorism, due to the high impact of his attack, is Anders Breivik. Breivik killed 77 individuals on 22nd July 2011, in targeted attacks amid the Regjeringskvartalet in Oslo and on the island of Utoya. However, the high degree of sophistication evident in the planning, preparation and commission of his attack makes him an exceptional case. Firearms are commonly used, which require only a small amount of training and are easily accessible in some countries such as the U.S. (Jasparro, 2010; Spaaij, 2010; 2012; van der Heide, 2011; Gruenewald et al., 2013a; 2013b; Schuurman et al,, 2018). Vehicular assaults are also popular (Jasparro, 2010), and, along with bladed weapons, seem to be the modus operandi of choice in attacks inspired by ISIS over the past few years. This further demonstrates a preference for low-skilled and easily attainable weapons.

Lone actors tend to conduct reconnaissance of potential targets which also offers potential for disruption (Gill, 2015). A substantial amount of time taken for

planning and preparation seems to be a general characteristic of lone actors, although the degree varies from case to case. Schuurman et al. (2018) found the planning and preparation of lone actor attacks to be a lengthy process, typically taking several months. Lone actors appear to be more strongly driven by personal grievances, which may influence their target choices (Gill, 2015). It seems that targets are selected at an early stage during the individual's preparation process (Gill and Corner, 2016; Schuurman et al., 2018) and a better understanding of what happens before and during the attacks will strengthen disruptive and preventative efforts. In an analysis of 84 lone actor terrorists, Becker (2014) found that most actors were able to select targets in a logical manner, regardless of whether they were suffering from mental or psychological problems.

To date, no research has analysed the spatial patterns of lone actors. This is a critical oversight. One study of lone actor target selection has touched upon the concept of awareness space, however the methods used were mostly qualitative (Becker, 2014). More than half of the sample studied had an identifiable geographical connection to the target. However, this was not quantified, area limits were not defined, and the author only states whether they were familiar with the target area. There may also be variances in target selection for individuals who have different ideologies. For example, lone actors with a single-issue ideology (e.g environmentalists, anti-abortion activists) are more likely to be fixated on a particular target due to the specific nature of their grievance.

The points outlined in this section offer many opportunities for disruption, however they are of limited utility by themselves. An analysis of spatial patterns and any potential geographical constraints is needed to fully understand the decision-making processes regarding target selection. This may provide important insights into their decision making regarding target selection, thus providing knowledge to guide and improve the efficacy of methods to counter violent terrorist events. Therefore, the first analysis of this thesis aims to establish if the distance decay pattern consistently found for urban crime and identified in group terrorism is reflected for lone actor attacks.

2.5 Northern Ireland related terrorism

The second set of analyses conducted in this thesis (chapters 4, 5 and 6) focus upon attacks in Northern Ireland carried out by contemporary violent dissident Republican (VDR) groups and the Provisional Irish Republican Army (PIRA). The aim is to expand on the existing knowledge regarding spatial patterns and target selection of group actors and explore decision making at the micro level.

Since the Anglo-Irish treaty in 1921 Northern Ireland has been the setting for political violence from different Irish republican paramilitaries, with the mutual aim of removing British rule. The most heavily researched period of the Northern Ireland conflict over the past 100 years has been 'The Troubles'. From 1970 until the signing of the Good Friday Agreement in 1998, PIRA were at the forefront of a violent ethno-nationalist campaign[10]. The main targets of their campaign were the police and the British Army. The threat was not contained to Northern Ireland, with attacks occurring in parts of the Republic of Ireland, England, and mainland Europe[11].

Differences in policies and targeting between the subunits of PIRA have been observed. Attacks with high casualty numbers and on high value targets were more likely to be caused by the subunits of PIRA that contained individuals with relevant skills such as bomb making (Asal et al., 2015). Several studies have produced descriptive statistics on the spatial and temporal distribution of attacks in Northern Ireland (including Poole, 1995; O'Duffy 1995; McKittrick et al., 2001; Morrissey and Smith 2002; O'Leary, 2005). However, research has neglected to include the alternatives that could have been chosen but were not. For example, when examining the distribution of attacks in Belfast it is evident that deaths were higher in extremely divided parts of the city, however there were many other

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[10] There were several other Republican militant groups that were active during this time, including the Official Irish Republican Army, the Irish National Liberation Army, the Continuity IRA, the Real IRA, and the Irish People's Liberation Organisation, however PIRA were the most prolific during this time.

[11] For a detailed history of 'The Troubles' see English. R. (2003). Armed Struggle: The History of the IRA. London: Pan.

areas that were equally as divided that experienced very few attacks (Mesev et al., 2009). Attacks by PIRA in the 1970s appeared to be indiscriminate and resulted in a substantial amount of civilian casualties (Horgan and Taylor, 1997). A large proportion of PIRA's attacks did not cause fatalities. Just 8.7 percent of improvised explosive devices killed at least one person, and in many cases the victim was the bomb planter.

As it is evident that attacks committed by PIRA were dependent on the decision making of the individual (Asal et al., 2015), analyses may provide further insight to processes of individual target selection. The longevity of their campaign provides a wide scope for data. To date, most analyses concerning group terrorism have been analogous to traditional spatial and temporal modelling methods guided by crime pattern theory, with the aim of identifying spatial concentration and diffusion of attacks. Findings have demonstrated that group attacks are largely concentrated to specific areas within countries. For example, LaFree et al. (2012) found attacks by ETA to be heavily concentrated in Basque Autonomous Community. Likewise, Northern Ireland related terrorism has been highly concentrated in Belfast (Fay et al., 1999). However, spatial analyses seldom go beyond the regional level. The study of group actors could hugely benefit from more detailed spatial analyses to provide more depth and add a practical element to guide interventions.

PIRA's campaign ceased in 1997, however other contemporary dissident republican terrorist groups who reject the political process in Northern Ireland continue to be a threat. The two main paramilitaries[12], the Continuity IRA (CIRA) and the New IRA, as well as multiple smaller factions, all presently regard violence as a legitimate means of achieving a united Ireland (Frampton, 2011, 2012; Bean, 2012; Evans and Tong, 2012). In January 2007, Sinn Féin (the political wing of PIRA) made the historic announcement of their acceptance of the Police Service of Northern Ireland (PSNI) as the legitimate police force of

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[12] Óglaigh na hÉireann (ONH) was also a prominent VDR group until they called a ceasefire in early 2018.

Northern Ireland. Since then there has been a steady rise in paramilitary violence from VDR groups. These groups fundamentally oppose republican engagement in the wider peace process and this acceptance of the PSNI (Horgan and Morrison, 2011; Morrison and Horgan, 2016). VDR groups want to demonstrate that the 1998 Good Friday Agreement has failed.

Targeting of the security services remains a prominent feature of dissident Republican violence. In March 2009, Stephen Carroll became the first police officer to be killed since the Good Friday agreement. The Continuity IRA stated the following in their claim of responsibility: *"As long as there is British involvement in Ireland, these attacks will continue."* To discourage others from joining the police, VDRs have focused on the targeting of Catholic and nationalist officers (Morrison and Horgan, 2016). This reinforces their characterisation of an unrepresentative police force, demonstrating that, to them, the British police force is illegitimate, and is a means of setting themselves apart from Sinn Féin.

Although their campaign has thus far has been less intensive than that of PIRA, they still continue to target the British Army and PSNI, the successor of the Royal Ulster Constabulary (RUC), and pose a 'severe' threat to Northern Ireland.[13] Their activity demonstrates a rising sophistication in strategy and expertise. They have become increasingly competent in producing viable devices, and have incorporated the use of bomb hoaxes (fake devices) into their strategy, which cause distress to the public and occupy the resources of police services. A variety of attack methods have been incorporated throughout their campaign, thus allowing for more comparisons to be made regarding incident type.

The current threat from VDR groups is characterised by a parallel strategy of nationalised terrorism alongside localised violent vigilantism (Morrison and Horgan, 2016). Belief of 'responsibility' to defend and protect their community is a key component of modern Republican ideology (O'Doherty, 1998). This covers both protection from Loyalist violence, and protection from anti-social behaviour

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[13] Current threat level at time of writing according to the UK's security service (MI5).

and crime within the community (McEvoy and Mika, 2001). However, for the most part, modern day VDR activity has not seen any significant engagement with Loyalist paramilitaries. Paramilitary groups claim to better represent the local communities than the PSNI - who they reject as a legitimate police force - and have taken it upon themselves to enact forms of vigilante justice on local criminals such as sex offenders and drug dealers. These 'punishment attacks' can also act as a form of internal policing within the groups themselves, i.e. the punishing of suspected informers. These are not acts of terrorism, rather acts of violence committed by terrorists, to gain support and power within their community.

To date, the literature surrounding VDR related terrorism has been largely descriptive. To the author's knowledge, at present there is only one study that looks specifically at the targeting strategy of contemporary VDR groups. Morrison and Horgan (2016) conclude that it is civilians who are most at risk for violence (especially post 2009), and can be considered the dominant target of the VDR campaign. Out of 1007 violent acts examined in this study, 63.5% were attacks against civilians. Police and intelligence personnel and facilities were the second most targeted category. The decision-making of VDR groups regarding target selection appears to be a well thought out process, and there are distinct differences when comparing the methods and objects of attacks (Morrison and Horgan, 2016). Morrison and Horgan (2016) conclude that methods of environmental criminology can be useful in understanding target selection. However, to the author's knowledge, analyses of spatial patterning of VDR activity do not exist.

2.6   Conclusion

This chapter has given an overview of the environmental criminological literature relating to spatial patterns, and demonstrated how these paradigms may have utility in the study of terrorism. It has highlighted the paucity of literature and analyses related to the spatial decision making of lone actors, and exposed gaps

in the literature concerning group actors. Over the past decade, studies which apply methods from environmental criminology to terrorism have increased in number and improved in sophistication. What has been neglected however, is the use of methods at the micro level, which arguably has the most utility for preventative techniques.

Whilst the above studies collectively contribute to our knowledge of some of the main threats to the UK at present, there is little to guide practical prevention and intervention measures. Most spatial research has thus far been oriented towards group terrorism, with the aim of identifying hotspots that can aid in the effective use of resources to counter the threat using macro and meso analyses. There has been a tendency to focus on macro level analyses of spatial patterns, which, while useful for ascertaining patterns of group terrorism and insurgency, offer little insight to the decision making of individuals. Micro levels offer the most utility for the application of environmental criminology. To date, no research has empirically analysed spatial patterns of lone actors, however one study of lone actor target selection has touched upon the concept of the awareness space. There has been some insight that suggests group actors behave spatially in a similar way to urban criminals, but we know very little about whether this can also be applied to lone actors.

This thesis will expand on existing research, with a view of gaining a better understanding of the spatial decision making of individuals involved in terrorist acts. An increased knowledge of spatial patterns at the micro level will be extremely useful in the guidance of prevention efforts. The next chapter examines how far lone-actor terrorists travel to commit their attacks, and establishes whether the distance decay pattern that is evident for urban crimes and group terrorism is replicated in lone-actor terrorism.

Chapter 3   Residence-to-attack analyses of lone-actor terrorists

3.1   Introduction

There has recently been a considerable increase in research into lone-actor terrorism (e.g. Gill et al., 2014; Gill, 2015; Corner and Gill, 2015; Spaaij and Hamm, 2015; Meloy and Gill, 2016; Pantucci et al., 2016; Ellis et al., 2016; Schuurman et al., 2018). However, attack execution is one of the main areas that remains understudied. Terrorists, just like urban criminals, are limited by geographical constraints, and numerous patterns of spatial clustering that are evident for traditional crimes are reflected in terrorism (Clarke and Newman, 2006). If terrorists are selecting targets in a rational manner, then the spatial distribution of attacks should be non-random. When examining terrorist attacks, it is evident that they do not occur randomly across time and place.

To date, geographical research into terrorist target selection has largely concentrated on establishing how terrorist attacks are spatially distributed, whether they are concentrated to specific areas, and determining variations in risk (Townsley et al., 2008; Rossmo & Harries, 2011; Braithwaite & Johnson, 2015; Tench et al., 2016). Other studies have identified temporal variations in spatial patterns, such as changes in incidents and intensity of attacks per the changes in strategy of the organisation, or increases in attacks due to symbolic dates or special events (Hafez and Hatfield, 2006; Siebeneck et al. 2009). There have been several target based studies of this nature for group terrorism (Berrebi and Lakdawalla, 2007; Siebeneck et al., 2009, Webb and Cutter, 2010; Medina et al., 2011; LaFree et al., 2012), but spatial patterns of group terrorism such as clustering and hotspots are unlikely to be replicated for lone attacks. Further, target based approaches are constrained as they are based solely on attack locations and attributes, and any information about the offender such as their home location is disregarded. It is therefore assumed that other factors, such as

distance to the target, have no effect on decision making (Bernasco, 2007). Further, these approaches assume that the spatial distribution of offenders' homes is equally spaced (Bernasco, 2007) which has extremely limited utility for strategies aimed at interdiction.

A more in depth understanding of the spatial decision making of lone-actor terrorists is needed to guide practitioners. Geographical constraints may be amplified for lone actors, who are likely to lack the resources and support that would be available to them if they belonged to a larger network. This lack of resources limits a lone actor's capability (Boyns and Ballard, 2004), and may restrict the sophistication of the attack, which is dependent on the individual's level of expertise, skills and knowledge (Gill & Corner, 2016). Whilst studies have highlighted that lone actors typically 'leak' their plans to close associates, and that this has much relevance for prevention measures, its utility is rather limited by itself (Gill, Horgan and Deckert, 2014; Gill, 2015). However, if this knowledge could be coupled with practical knowledge such as patterns of spatial decision making, it may be useful to narrow down potential targets and further aid preventive measures.

One of the most fundamental relationships in environmental criminology is that of spatial interaction and distance. Geospatial research on crime is typically guided by the least effort principle (Zipf, 1965), which assumes that when an offender is considering several options for action, he (or she) "selects the one closest to him in order to minimize the effort involved" (Lundrigan and Czarnomski, 2006, p.220). Journey-to-crime research of urban offences such as burglary illustrates clear and consistent patterns, where the frequency of offences decreases as the distance from the home increases. When considering the rational choice perspective, on a basic level an offender should choose a shorter distance over a longer one, to minimise time and effort. As lone actors lack the resources and support of a wider network it is likely that they will keep distances travelled minimal, to increase the utility of their attack (Clarke and Newman, 2006).

This chapter examines distance as a constraining factor on lone actor events and seeks to identify whether the distance decay pattern that is consistently observed in traditional crimes is also apparent in acts of lone-actor terrorism. Quantitative analyses will be run to compare differences between continent attacked (Europe/U.S.), ideologies, types of targets and weapon use.

3.2 Theory

3.2.1 Journey-to-crime

The theoretical basis of this chapter stems from crime pattern theory and the concept of the awareness space (Brantingham and Brantingham, 1981; 2008). As an individual navigates their city or town, travelling to and from their daily activity nodes (e.g. place of work, education or recreation), they become more familiar with these areas than other areas in their home town or city. Crimes will occur where the awareness space of an offender overlaps with an opportunity for criminal activity (Bernasco, 2014). As such, targets are typically selected close to these activity nodes (Ratcliffe, 2006).

Traditional journey-to-crime research for urban crimes illustrates clear and consistent patterns, with distance being a key criterion that the individual considers when choosing a target (Bernasco and Block, 2009). In 1932, White conducted the first systematic analysis of crime journey distances and since then distance-to-crime has been studied extensively. Typically, for urban offences, journey-to-crime distances demonstrate a distance decay pattern, whereby the frequency of offences decreases as distance from the home increases. In the case of several equally attractive alternatives, an offender generally prefers the one geographically closest to them. Closer targets take less time and effort to reach, and they therefore offer more utility to the offender (Bernasco, 2014).

For urban crimes, such as robbery and burglary, mean journey lengths are generally short. The average journey-to-crime distance is less than two miles, and target locations are usually within one mile of the offender's residence (White, 1932; Harling 1972; Barker, 2000; Rossmo, 2000; Costello and Wiles, 2001).

These results are consistent across crimes (Harling, 1972), as well as over time and space, with similar results for similar crime classifications demonstrated over four decades (White and Clyde, 1932; Pyle et al., 1974). Most studies use police-recorded data of incidents, using Euclidean (straight line) or Manhattan (city block) methods to calculate the distance between the offender's home address and the location of the crime event. Results usually demonstrate a pattern in number of offences on a per-unit basis, where the frequency per unit decreases as distance from the home location increases (Georges-Abeyie and Harries, 1980). van Koppen and Jansen's (1998) analysis of robberies in the Netherlands displayed a clear distance decay pattern. Bernasco's (2006) findings also demonstrated the distance decay effect in both individual and co-offender residential burglaries.

Similar results have been found for crimes against persons, where the individual's motives and actions are primarily guided by emotion (Brantingham and Brantingham, 2003). The spatial behaviour of serial killers shows logic (Lundrigan and Canter, 2001). Their target selection is strongly related to their awareness space, whereby they are most likely to come across their victims during their daily routines (Godwin & Canter, 1997). Evidence of distance decay has also been found for rapes and homicides (Rhodes and Conley, 1991; Warren et al., 1998; Laukkanen and Santtila, 2006; Santtila, Laukkanen and Zappala, 2007). Davies and Dale (1995) found that the majority of rapes occurred within the immediate vicinity of the home, with a reduced frequency of offences as distance increased. When examining individual cases rather than averages of a particular crime type a similar result is found. LeBeau (1987, 1992) found that serial rapists returned to the same location to carry out their attacks, and that these locations were in areas that were familiar to them.

Terrorist organisations make carefully calculated choices that are value-maximising and guided by logic (Asal et al., 2009), with the intention of increasing their probability of success (Hoffman, 2006). There is evidence to suggest that there is a calculation of perceived risks in the selection of targets in terrorist organisations at the group and individual level (Mickolus, 1980; Sandler et al.,

1983; Sandler and Lapan, 1988). For group terrorism, proximity to the target has been considered a key feature of target selection (Clarke and Newman, 2006), and will be one of the criteria that the individual considers when choosing a target (Bernasco and Block, 2009). Clarke and Newman's (2006) review of counter-terrorism strategies concluded that terrorists are limited by geographical constraints in the same way as more traditional criminals. It is likely that they will keep distances minimal, to increase the utility of their attack (Clarke and Newman, 2006). However, many of Clarke and Newman's proposals are yet to be empirically tested.

LaFree, Yang and Crenshaw (2009) concluded that 96% of domestic anti-U.S. attacks between 1970-2004 involved local targets close to terrorists' homes. Cothren et al., (2008) found that 46% of group attacks in the U.S. took place within 30 miles of the home location. Eby's (2012) analysis of 53 lone actors in the U.S. found a large range of distances between home and target locations. Many of the individuals remained in their hometowns in their attack attempts, although six of the sample travelled extremely long distances. Becker (2014) examined 84 lone actors in the U.S. between 1940 and 2012. Most actors in this study appeared to select targets in a logical manner. The concept of the 'awareness space' of an individual was considered and 60% of the sample studied had an identifiable geographical connection to the target. However, this was not quantified, area limits were not defined, and Becker only states whether they were familiar with the target area. A recent examination of attacks by PIRA found that nearly two thirds of the sample travelled less than 4 miles to commit their attacks, with 40% of all attacks occurring within 1 mile of the offender's home location (Gill et al., 2017). Lone actors are likely to have a lower capability than terrorist groups due to a lack of skills, support and resources. Therefore, it is likely that distance acts as a constraining factor on their target selection. As such, it is hypothesised:

H1: The frequency of lone actor attacks will decrease as residence-to-attack distance increases.

From research into group terrorism it is clear that human capital is very valuable in the preparation and execution of an attack. A higher level of organisation and expertise is needed to successfully carry out complex attacks (Asal & Rethemeyer, 2008; Jackson & Frelinger, 2009). Individuals with command and control links with a wider network may travel further to more complicated targets if they have support from others. More engagement with others is likely to lead to more skills and knowledge, increased awareness of potential targets, and the ability to perpetrate a more complex attack. Given this, it is hypothesised:

H2: Lone actors with links to a wider network will travel further than those without.

3.2.2   Europe vs. U.S.

A limiting factor of previous research into journey-to-crime patterns of terrorism is that most studies only consider U.S. cases. It is probable that the spatial patterns are different when comparing the U.S. to Europe as the distribution of available and relevant targets is likely to be different. The U.S. has a much lower population density, is a much larger country, and the distribution of 'points of interest' such as commercial centres is different. Many of the cases used in previous samples were living in rural or isolated areas, therefore it would make sense for them to travel greater distances.

Traditional journey-to-crime studies have found differences in distance travelled between crimes committed in the U.S. and Europe. For example, when examining serial murderers, victims were killed an average of 1.5 miles from the home location of the perpetrator in Europe, compared with an average of 14 miles in the U.S. (Rossmo, 2000). Given these findings, it is hypothesised:

H3: Lone actors will make longer residence-to-attack journeys in the US than in Europe.

3.2.3 Target Type

For lone actors, it is likely that some consideration will be made regarding the availability of 'good' targets which are also suitable for their goals (i.e. representative of their ideology) and that they may travel further for targets of higher value. Regarding geographical constraints, there is likely to be a trade-off between costs and benefits in the selection of the target, with the cost being the distance travelled and the benefit being the value of the target. It is likely that the balance of the value to be gained against the increased travel time required is assessed before selecting a final target.

Eby (2012) looked at successful and failed attacks in the U.S. He highlighted that there was a negative association between success and distance travelled. However, 'success' was defined in terms of how many casualties occurred as a direct result of the attack. One of the main difficulties associated with lone-actor attacks are their idiosyncrasy. It cannot be concluded that every lone actor's goal or aim is to cause mass casualties. Gill et al.'s (2017) PIRA study found targets deemed to be of high value (i.e. government officials), were associated with much longer distances than low value targets, (i.e. ordinary citizens). It can be proposed that lone actors will travel furthest for an iconic target, as this has the most representative value:

H4: Lone actors will travel further for iconic targets than symbolic or arbitrary targets.

Additionally, lone actors may choose to attack unfamiliar areas if the selected target is more in line with their ideology (Bakker & De-Graaf, 2010; Moskalenko & Mccauley, 2011; Wright, 2013; Gill, Horgan & Deckert, 2014). As such, it is hypothesised:

H5: Lone actors will travel further for symbolic targets than arbitrary targets.

Complex attacks, such as those on iconic targets with high levels of security are likely to be beyond most lone actors' individual capability. The level of protection and difficulty in accessing these types of targets increases the complexity of the attack, which is amplified for lone actors as they lack human capital. 60% of Becker's (2014) sample chose civilian targets. Hard targets, such as governmental or military targets, tend to be avoided (Spaaij, 2012; Borum, 2013; Becker, 2014; Gill and Corner 2016). When considering this alongside previous findings that lone actors are more likely to attack 'soft' targets such as civilians, and that most attacks occur in public locations (Gill et al., 2014), it is expected that most attacks will be of a symbolic nature. Therefore, the 'symbolic' subgroup will also be examined separately to enable further inferences to be made between symbolic buildings and symbolic persons.

The distance offenders are willing to travel for urban crimes can vary depending on the characteristics of the crime event. Crimes against properties usually require more planning and tend to involve longer distances than crimes against individuals which are often of an opportunistic nature (Repetto, 1974; Capone and Nichols, 1976; Brantingham and Brantingham, 2003). Variations found in traditional journey-to-crime distances suggest that there is a real or perceived difference in opportunities for different crime types, and violent crimes against persons are associated with shorter distances than property crimes (Hesseling, 1992). Traditional criminals will travel further if targeting specific victims or target types (Fritzon, 2001), for crimes that are more instrumental (Santilla et al., 2007) and for sophisticated targets if the monetary incentive is higher (van Koppen and Jansen (1998). Property crime is associated with longer distances travelled if the expected value of the outcome is higher (Pyle, 1974; Repetto, 1974; Baldwin and Bottoms, 1976; Rhodes and Conly, 1981; Hesseling, 1992; Tita and Griffiths, 2005), with a positive relationship between distance travelled and the value of property stolen (Snook, 2004; Morselli and Royer, 2008).

Where terrorist attacks are concerned, there is often overlap in the targeting of people and property, and it is difficult to distinguish between these two groups. However, it can be proposed that wherever persons are targeted at a symbolic

building that the individual has chosen this location due to the perceived number of available and relevant targets associated with it (for example if a mosque is targeted and individuals of the Muslim faith are attacked), and therefore the expected value of the outcome is higher. It is therefore hypothesised:

H6: Lone actors will travel further where a symbolic building is present compared with when a symbolic building is not present.

3.2.4 Ideology

One factor that hinders the prevention of lone-actor attacks is the wide spectrum of grievances and motivations of the perpetrators. Their varying ideological beliefs will influence their goals, and thus will influence their target selection. Many distinguishable differences have been identified when comparing ideological subgroups of lone actors. This is not limited to demographics, and factors such as variances in skill acquisition and preparation for the attacks are significantly different (Gill et al., 2014).

This study will therefore disaggregate by ideological group in an attempt to identify any differences in spatial patterns concerning target selection across different motivations. Target choices should be governed by the individual's grievance or ideology (Drake, 1998), be reflective of the message they want to communicate (Hoffman, 2006), and elicit a response from their target audience (O'Neill, 2005). Therefore, it is likely that some consideration will be made regarding the availability of 'good' targets that are also suitable for their cause. This will act as a further constraining influence on their selection of targets from an otherwise 'unlimited' choice set.

Those with single-issue grievances may have a limited choice set when compared to other ideologies, and may be more likely to travel further afield and beyond their awareness spaces. For example, anti-abortionists in the U.S. may be forced to travel to different states due to the varying legality of abortions in

different states. The individual may be willing to travel further, and to unfamiliar areas, to commit an attack on these targets. Ideology can therefore be considered a limiting factor in target selection, and as such it is hypothesised:

H7: There will be differences in distance travelled between different ideological groups.

3.2.5 Weapons

Weapon choice is guided by cost-benefit analyses. Although bomb-making manuals are becoming more easily available online it is still difficult for a lone individual to successfully build a bomb. The successful construction of an improvised explosive device (IED) is very complex (Asal et al., 2015) and requires more expertise and planning than other weapons (Johnson and Braithwaite, 2009). Due to a lack of skills and resources lone actors tend to rely less on this weapon type than group actors (Spaaij, 2010), and are more likely to use weapons that are easy to obtain and operate, such as firearms and edged weapons such as knives and axes (Gruenewald et al., 2013).

Lone actors may lack the capability to pull off sophisticated attacks and may be constrained by several factors including limited skillsets and a lack of support and resources of a larger group. These limiting factors are reflected in their weapon choice and a tendency to target softer targets such as civilians. The type of weapon used will have a constraining effect on the type of target that can be chosen, with different types being more or less appropriate for each weapon (Clarke and Newman, 2006). It is therefore hypothesised:

H8: Individuals will travel further when using a bomb as their main weapon than when using a firearm or bladed weapon.

3.3 Data and Method

To test the hypotheses and to perform the analyses a database of lone-actor terrorists was constructed using parts of an existing dataset (Gill et al., 2014) as well as additional data obtained from open source literature. Independent coders had collectively spent 5500 hours working on data collection and coding for the existing dataset (Gill et al., 2014), which contained 119 cases (individuals) and 185 variables (including demographic information; details about the selected target and weapon used; details of mental illness; preparatory behaviours; criminal history; whether the individual had face-to-face or virtual contact with a wider network, and so on). Each observation was recorded by three independent coders, then results reconciled in two stages (coder A with coder B, then coders AB with C). Most of the material was sourced using LexisNexis (e.g. media reports, scholarly articles, published biographies). Where data was missing in the dataset, the same procedure was followed for the additional data collection.

To qualify for inclusion for the subsequent analyses of this chapter, the attack had to be ideologically motivated and committed by a lone offender who was either apprehended or killed in the commission of their offence in the U.S. and western Europe since 1990. Lone actors who were apprehended in the planning phase of their attack were removed from the dataset due to the nature of the analysis (n=39). To be included in the final working dataset the actor's accurate home and attack(s) location had to be known (10 cases were removed at this stage). If the home location and attack location were in the same town or city and the street address for the home location was unknown the case was removed from the dataset (n=3). In the very few (n=2) instances where an accurate street address for the individual was unknown, but they travelled to a different town or city, the geometric centroid of their home town or city was used. Any other known location data were recorded if available, such as the individual's place of work or higher education, place of worship and previous address(es).

The final dataset consisted of 122 attacks committed by 70 individuals. Incidents included shootings, bombings, arsons and vehicular attacks. The author deemed

the amount of data for arson and vehicle attacks to be insufficient and so these cases were removed from the sample for the analyses pertaining to weapon choice. Residence-to-attack distances were computed for each attack using the home and target locations using Euclidean straight-line distance (the shortest distance between two points). This technique was used as opposed to road network distance due to the retrospective nature of this study and the irregularity of the street networks (whereas Manhattan distance is typically used for gridded street networks). This measurement is also typical of other similar studies (e.g. van Koppen and Jansen, 1998; Beauregard et al., 2007; Santilla et al., 2007). The variables indicating whether the individual had face-to-face communication and virtual communication with others were dichotomously coded.

Target choices were coded as either iconic, symbolic or arbitrary by two coders. Iconic targets were defined as persons or buildings that were regarded as an ultimate representative symbol of the individual's ideology, or a unique building or location. Symbolic targets were other buildings or persons that would serve as a symbol of the individual's grievance. Examples of iconic buildings could include the Pentagon or the White House, or areas such as Times Square in New York City. An example of a symbolic building could be a mosque, synagogue or military base and a symbolic person could be a member of Parliament or member of the military. The single-issue subgroup included many anti-abortion activists. For these individuals, an iconic target was defined as a clinic or doctor that performed *late-term* abortions. All other abortion clinics and doctors were regarded as symbolic targets. The arbitrary subgroup included indiscriminate attacks where there was no obvious connection between the target of the attack and the individual's grievance.

For the symbolic subgroup, cases were coded as 'building' or 'persons'. Buildings included all cases where the attack took place at a symbolic building, regardless of whether the object of the attack was the building itself, and symbolic persons were defined as an event where no symbolic building was involved.

Cohen's K was run to determine the agreement between two coders' judgement

on whether the targets should be considered as iconic, symbolic or arbitrary. The results reflected a substantial agreement between the two coders (k = .768, p < .001). The disagreements were discussed and resolved, and these resolved codes were used for subsequent analyses.

3.4 Results

3.4.1 Descriptive Statistics

Table 3.1 summarises the accumulative percentages of attacks within different distance ranges. The mean distance of attacks from the actor's home was 90 miles (144km), however more than half of all the attacks (56.5%) occurred within 10 miles (6km) of the individual's home location, and 36% of all attacks occurred within 2 miles (3km).

Individuals categorised in the single-issue group appeared travelled the furthest and Islamists travelled the shortest distance. Clear differences can be seen for the mean journey lengths for Europe and the U.S., and individuals travelled much further when attacking iconic targets.

Table 3.1. Accumulative percentages of attacks aggregated by location, ideology and target type

	Mean (miles)	Within 1 mile	Within 2 miles	Within 5 miles	Within 10 miles	Within 20 miles	Within 50 miles
All *(n=122)*	90	21.5%	36%	48.5%	56.5%	66.5%	77%
Europe *(n=57)*	15.5	35%	56%	70%	75.5%	82.5%	93%
USA *(n=65)*	155	9%	18.5%	29%	40%	52%	63%
Islamist *(n=35)*	27	29%	34.5%	40%	54.5%	71.5%	83%

Europe (n=18)	34.5	44.5%	50%	55.5%	61%	67%	78%
USA (n=17)	19.5	12%	18%	18%	47%	76.5%	88%
Right wing (n=64)	35	22%	44%	59.5%	67%	72%	83%
Europe (n=38)	6.5	32%	60.5%	79%	84%	89.5%	100%
USA (n=26)	77.5	8%	19%	31%	42.5%	46%	58%
Single issue (n=23)	856	9%	17.5%	30.5%	30.5%	43.5%	52%
Europe (n=1)	20	0%	0%	0%	0%	100%	100%
USA (n=22)	1023	9%	18%	20%	32%	41%	50%
Iconic (n=18)	388	5.5%	5.5%	16.5%	22.5%	29%	50%
Symbolic (n=90)	39	21%	39%	50%	57%	67%	79%
Arbitrary (n=14)	3	40%	53.5%	73.5%	93.5%	87.5%	87.5%

3.4.2 Residence-to-attack

H1: The frequency of lone actor attacks will decrease as residence-to-attack distance increases.

To test the first hypothesis the distance values for each case were grouped into distance intervals and the frequencies of attack trips made to each of the different distances were calculated. The pattern is consistent with previous literature and displays a classic distance-decay curve. There is a highly positively skewed distribution, demonstrating that as distance from an actor's home increases, the number of attacks decreases (see figure 3.1). Due to the non-normal distribution of the data it was appropriate to use non-parametric tests for all subsequent analyses. A Spearman's correlation was run on this data to determine the

relationship between the number of attacks and distance travelled. There was a strong, negative monotonic correlation (r = -.628 p <0.01) between distance travelled and number of attacks.

Figure 3.1. Frequency of attacks within 20 miles of the home location
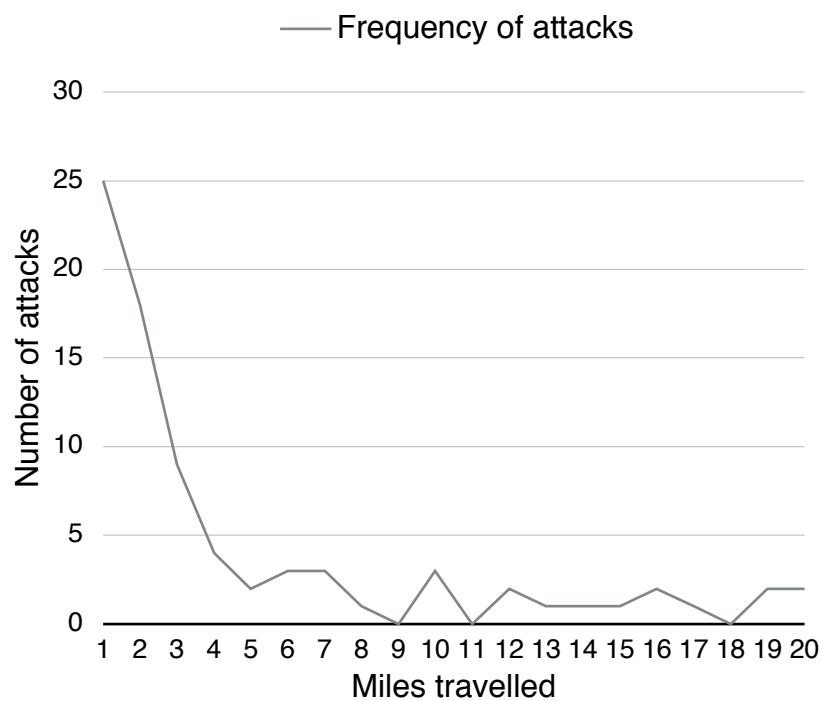
Some attacks took place within the immediate vicinity to the home location and there was no apparent 'buffer zone' (a threshold in the area immediately surrounding the offenders home in which fewer number of crimes occur) that is typically detected in many crimes but is largely absent for crimes of passion (LeBeau, 1987) and crimes of a personal nature (Davies and Dale, 1995).

H2: Individuals with links to a wider network will travel further than those without.

Communication with others was associated with longer distances. Those who had interactions with a wider network travelled much longer distances (mean = 130 miles/209km) than those who did not (mean = 69 miles/111km). A Mann-

Whitney *U* test indicated that this difference was highly significant (U = 1231.5 (z = -3.322), p = 0.001).

To examine this finding in more detail chi-square tests of independence were run to compare those who travelled short distances (up to 10 miles) and those who travelled long distances (11+ miles), based on a median split. A highly significant association was found between face-to-face interactions with members of a wider network and distance travelled, $\chi(1)$ = 13.246, *p* <.001. Based on the odds ratio, those who had face-to-face interactions were 4.04 times more likely to travel further than 10 miles than those who had no face-to-face interactions. However, there was no significant interaction between virtual interaction with members of a wider network and distance travelled, $\chi(1)$ = 1.082, *p* =.298.

3.4.3 Europe vs. US

H3: Individuals will make longer residence-to-attack journeys in the US than in Europe.

The mean difference travelled for Europe was 15.5 miles, compared with ten times that amount, 155 miles, for the U.S. A high concentration of attacks occurred around the actor's home in Europe, with more than half (56%) of all the attacks occurring within 2 miles of the home location. However, only 18.5% of attacks occurred within this vicinity for the U.S. 75.5% of attacks occurred within 10 miles in Europe, whereas just 40% of attacks occurred within this range in the U.S. Only 3.5% of attacks took place over 100 miles from the home location in Europe, compared with a quarter of U.S. cases. A Mann Whitney U test demonstrated that there was a highly significant difference between distance travelled for the U.S. (mean rank = 75.35) and Europe (mean rank = 45.70), U = 952 (z = -4.639), p <.001.

Journeys to commit an attack in Europe followed a clear distance decay pattern. A steep gradient of decline was found in the number of attacks adjusted to a per-mile basis from 0 to 4 miles from the last known home location of the actor. The number of attacks remained at a relatively stable, low number from the 10 mile point and became sporadic from 20 miles onwards. Very few offences (n= 5, <9%) were committed beyond 50 miles. A Spearman's correlation was run to determine the relationship between the number of attacks and distance travelled. There was a moderate, negative monotonic correlation ($r = -.570$ p <0.01).

Figure 3.3. Frequency of attacks in the U.S. within 20 miles of the home location at 1 mile intervals (n=34)

—— Frequency of attacks
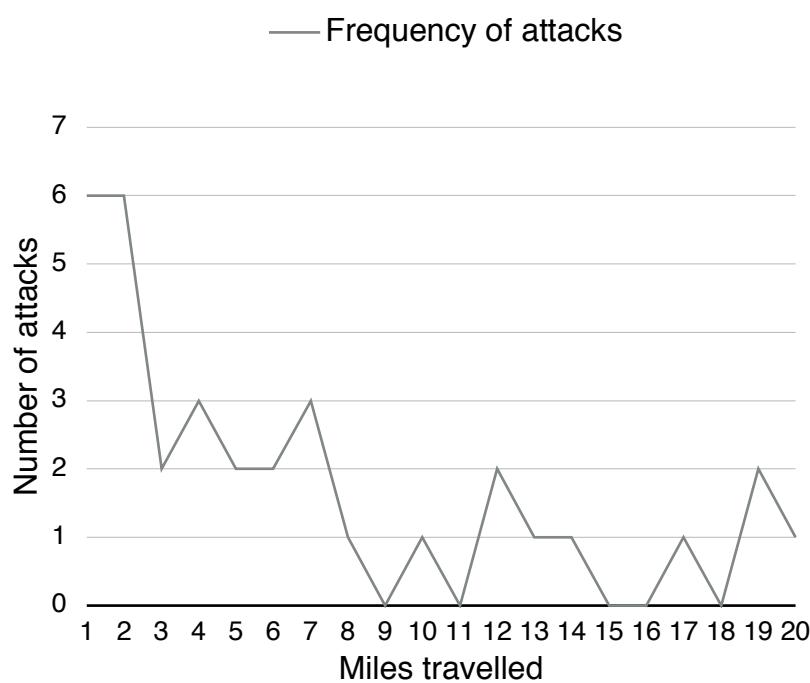
On examination of attacks per mile for the U.S. the results do not appear to show the same distance decay curve as Europe. However, this pattern becomes more apparent when transforming the intervals from 1 mile to 5 miles, and observing the journey lengths up to 50 miles. This finding suggests that individuals travel further to commit attacks in the U.S., but that that the decay pattern is still evident. This suggests that individuals are still affected by distance, but to a different degree than in Europe. This is consistent with traditional journey-to-crime studies, which have found differences in distance travelled between the U.S. and Europe. A Spearman's correlation was run to determine the relationship between the number of attacks and distance travelled. There was a strong, negative monotonic correlation distance travelled and attacks in the U.S. (r = -.651 p <0.01).

Figure 3.4. Frequency of attacks in the U.S. within 50 miles of the home location at 5 mile intervals (n=41)
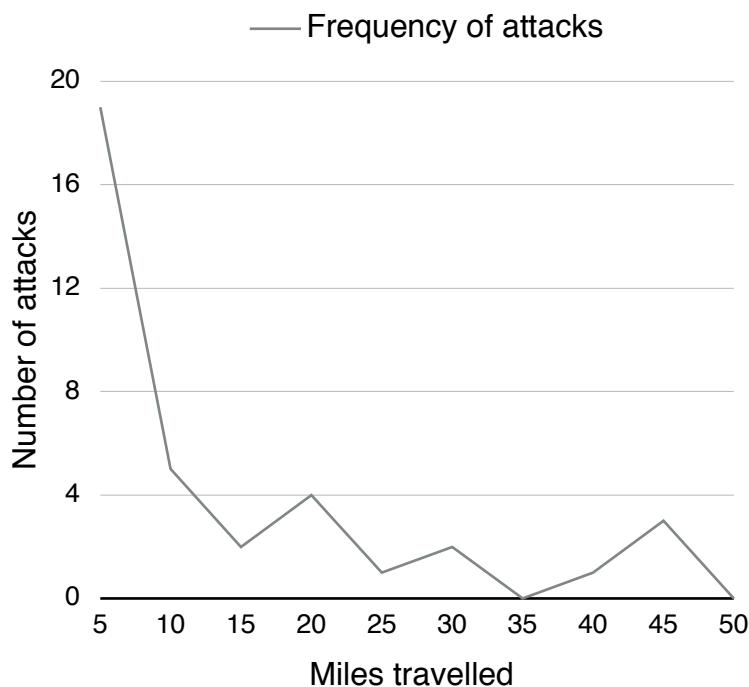
3.4.4 Target Type

H4: Individuals will travel further for iconic targets than symbolic or arbitrary targets.

H5: Individuals will travel further for symbolic targets than arbitrary targets

The mean trip length for iconic targets was much longer than for symbolic or arbitrary targets. Those attacking arbitrary targets travelled the shortest distance of the three target types. A Kruskal-Wallis H test showed that there were statistically significant differences in distance between the different target types, $\chi^2(2) = 19.084$, $p < 0.001$, with a mean rank of 89.78 for iconic targets, 59.79 for symbolic targets, and 36.11 for arbitrary targets. This indicates that lone actors are willing to travel furthest for an iconic target, followed by symbolic targets and arbitrary targets. It is likely that the attacks on arbitrary targets were more

spontaneous and involved less planning than the other attacks and therefore occurred closer to home. Also, as the targets were not symbolic it could be that the actor saw anyone as a legitimate target, which supports the theory that an individual will only travel further when no appropriate targets are available nearby.

Figure 3.5. Mean trip lengths (miles) of attacks aggregated by target type
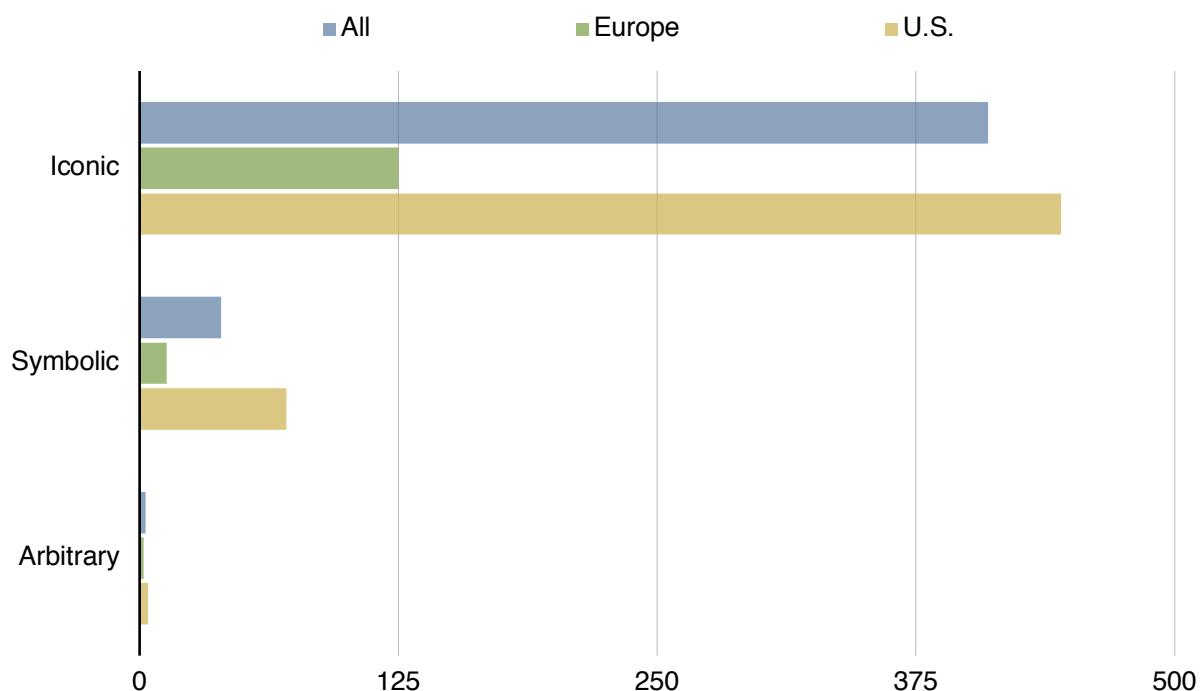
H6: Lone actors will travel further where a symbolic building is present compared with when a symbolic building is not present.

As most attacks could be considered symbolic further analyses were run to identify any distinguishing factors within this subgroup. A Mann Whitney U test revealed a highly significant difference for this group when comparing distance travelled for attacks in which a symbolic *building* was involved (mean rank = 39.17) and attacks where no symbolic building was involved (mean rank = 62.47), $U = 541$ (z = -4.014), $p < 0.001$.

3.4.5 Ideology

H7: There will be differences in distance travelled across ideologies

Two thirds of attacks on iconic targets were perpetrated by individuals with single issue grievances, the other third by Islamist extremists. No right-wing cases in this study committed attacks on iconic targets. More than half of the of the attacks on symbolic targets were committed by right wing extremists, and a quarter by Islamists. The remaining 17% were by single issue actors. Single issue actors executed no attacks on arbitrary targets.

A Kruskal-Wallis H test showed that there was a statistically significant difference in distance between the different ideologies, $\chi^2(2) = 13.899$, $p = 0.001$, with a mean rank of 57.71 for Islamists, 54.27 for right wing extremists and 84.74 for single issue terrorists. Lone actors with single issue ideologies travelled much further to their targets than the other two groups, with a mean distance of 856 miles, compared to right-wing extremists (mean = 35 miles) and Islamists (mean = 27 miles). There were noticeable differences when comparing single-issue actors in Europe (mean = 20 miles) to the U.S. (mean = 1023 miles).

Figure 3.6. Mean trip lengths (miles) of attacks aggregated by ideology
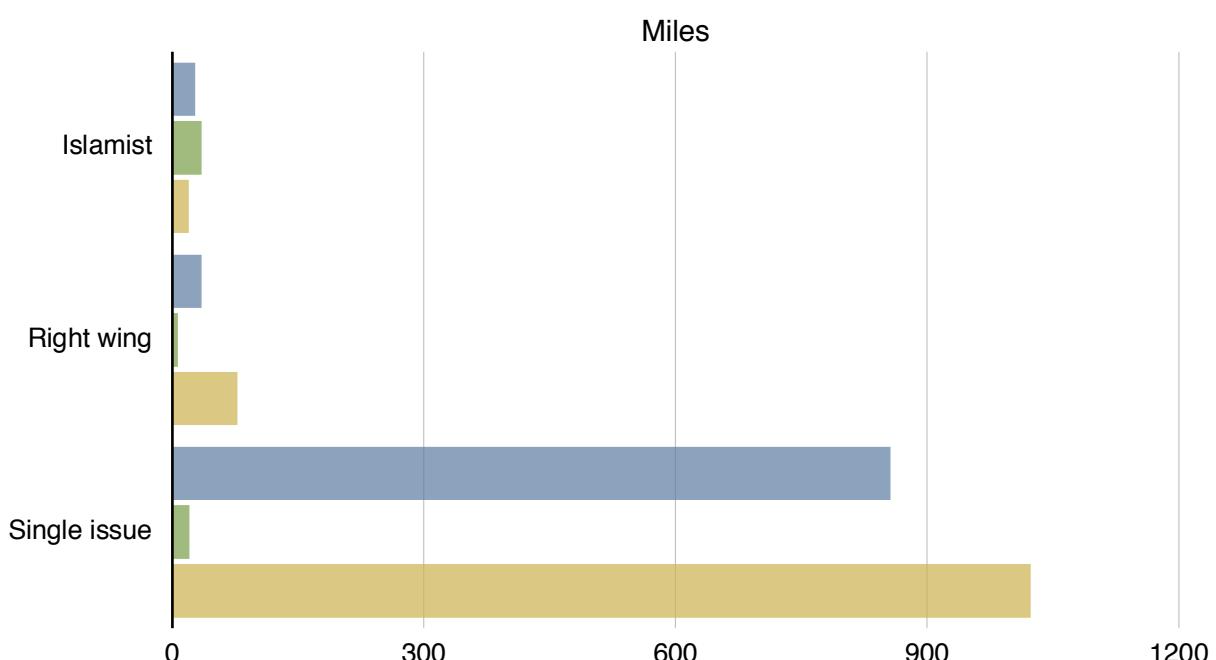
There was no significant difference in distance travelled between the Islamist and right wing groups, $U = 905.5$ (z = -1.152), p = .249, suggesting that the effects of distance are similar for these two subgroups. Therefore, further analyses were conducted using only Islamist and right wing cases. The mean for the remaining cases was 31 miles (compared to 90 miles for all attacks). A Mann Whitney U test revealed a significant difference for this combined group when comparing distance travelled in Europe and the US, $U = 647.5$ (z = -3.675), p < 0.001.

Table 3.2. Accumulative percentage of Islamist and right wing attacks

	Mean	**Within 1 mile**	**Within 2 miles**	**Within 5 miles**	**Within 10 miles**	**Within 20 miles**
All	31 miles	25%	41%	54%	64%	73%
Europe	15 miles	36%	57%	71%	77%	82%
U.S.	53 miles	10%	19.5%	29.5%	46.5%	61%

The distance decay curve for Islamist and right wing actors was to a higher degree than the analysis with all cases included, with a steeper gradient of decline (see figure 3.7).

Figure 3.7. Frequency of attacks within 20 miles of the home location for Islamist and right wing extremists
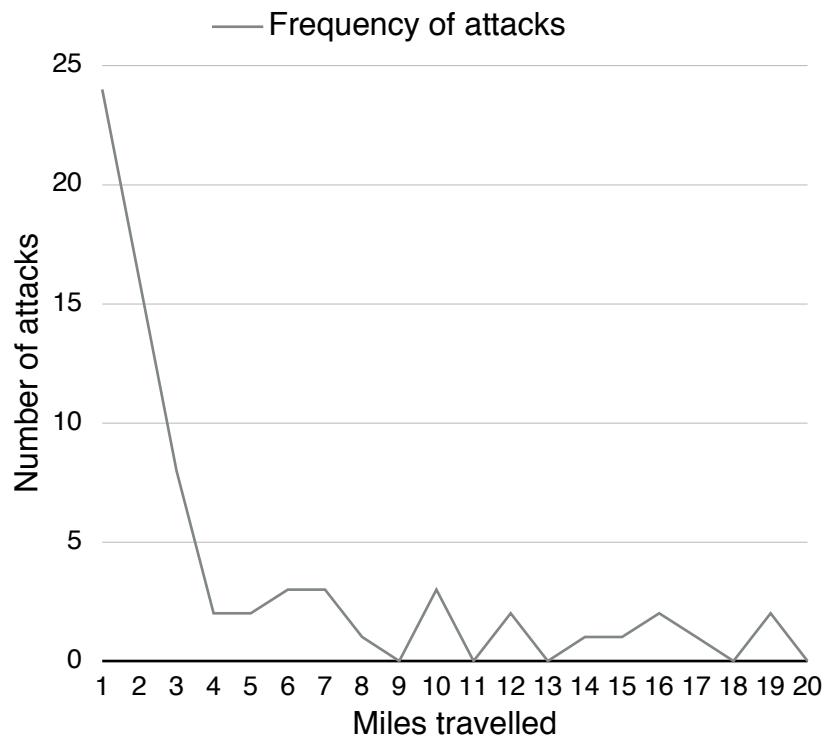
3.4.6   Weapons

H8: Individuals will travel further when using a bomb than when using a firearm or bladed weapon.

The mean trip length for attacks in which a bomb was used was higher than for a firearm or bladed weapon. To test for significance a Kruskal-Wallis H test was performed. The test was performed on the remaining three weapon types: firearms, bladed weapons and bombs. It demonstrated that there was a statistically significant difference in distance, $\chi^2(2) = 7.845$, $p < 0.05$, with a mean rank of 54.29 for firearms, 45.14 for bladed weapons and 74.63 for bombs.

Table 3.3. Mean trip lengths (miles) of attacks aggregated by weapon type

Mean trip length (miles)	Firearm	Bladed	Bomb	Arson	Vehicle
All	*138*	*76*	*148*	*171*	*10*
Europe	*8*	*84*	*83*	*-*	*-*
U.S.	*149*	*0.5*	*283*	*171*	*10*

Table 3.4. Summary of findings according to hypotheses

No.	Hypothesis	Findings
1	*The frequency of lone actor attacks will decrease as residence-to-attack distance increases.*	**Supported**
2	*Lone actors with links to a wider network will travel further than those without.*	**Supported**
3	*Lone actors will make longer residence-to-attack journeys in the US than in Europe.*	**Supported**
4	*Lone actors will travel further for iconic targets than symbolic or arbitrary targets.*	**Supported**
5	*Lone actors will travel further for symbolic targets than arbitrary targets.*	**Supported**
6	*Lone actors will travel further where a symbolic building is present compared with when a symbolic building is not present.*	**Supported**
7	*There will be differences in distance travelled between different ideological groups.*	**Supported**
8	*Individuals will travel further when using a bomb as their main weapon than when using a firearm or bladed weapon.*	**Supported**

3.5 Discussion

This chapter aimed to gain a better understanding of the processes that underlie the spatial decision making of lone actors, and identify whether they are constrained by distance in the same way as traditional criminals. The analyses expand the empirical knowledge of lone actor target selection and add a practical element that could aid in the development of intervention strategies. The main underlying theme for this is that, in any attempt to reveal insights into possible attack locations, each case needs to be considered individually according to the subgroups outlined above. It is also emphasized that there is a necessity to disaggregate lone actors in future research, and to consider subgroups, and any interactions these subgroups may have, i.e. the relationship between single issue actors and iconic targets.

The findings are very promising and distance can be highlighted as an important factor in target selection criteria, which is consistent with previous studies of terrorist activity (Clarke and Newman, 2006; Cothren et al., 2008; Gill et al., 2017) and traditional criminological studies (Wiles and Costello, 2000; Bernasco and Block 2009). The distance-decay pattern that is evident for urban crimes is replicated for lone actors, with the results demonstrating that frequency of attacks decreases as distance from home locations increase. These findings emphasise the value of incorporating methods of environmental criminology when modelling terrorism target selection. The results add further support for the argument that terrorists are rational thinkers when it comes to target selection. Becker's (2014) findings that lone actors are more likely to attack within their awareness space, and that an individual with the potential to commit an attack is likely to identify opportunities within their awareness space during their daily routines (Brantingham and Brantingham, 1981) were supported. Whether the decision regarding the final object of attack happens before or after they have decided to attack a particular *type* of target is yet to be determined.

Individuals with links to a wider network travelled much further than those without. Those who had face-to-face interactions were over four times more likely to travel

further than 10 miles. However, no significant difference was found for individuals who had virtual interactions with members of a wider network. This has important practical implications. If there is intelligence that a suspected potential offender has had face-to-face interactions with a wider network, it can be inferred that they may have the capability to travel further.

The constraining effects of distance are different for the U.S. and Europe. The results for both continents demonstrate the distance-decay pattern, but to a different degree, with individuals in the U.S. travelling much further than those in Europe. This finding held when examining Islamist and right-wing cases only, so it is not skewed by single-issue cases. The U.S. is much larger than European countries and has a lower population density, meaning potential targets may be distributed differently. The descriptive findings of accumulative percentages for distance travelled in Europe are particularly interesting. They are extremely similar to a U.K. Home Office study (Davies and Dale, 1995) into the geographical behaviour of stranger offenders in violent sexual crime. They found 29% of attacks to occur within 1 mile, 52% within 2 miles, and 76% within 5 miles, compared with 35% of attacks within 1 mile, 56% within 2 miles and 70% within 5 miles (76% within 10 miles) for the lone-actor attacks in this chapter. This provides further support for the argument that terrorists behave similarly to ordinary criminals in their spatial decision making.

Individuals travelled further for iconic targets than symbolic or arbitrary targets, and further for symbolic targets than arbitrary targets. This suggests that a consideration of costs vs. benefits may take place in decision making regarding target selection, and that there is a trade-off between distance to the target and the representative value of the target, as lone actors are willing to travel further for targets that are more in line with their grievance. Research has suggested that lone actors are not geographically constrained and are willing to travel long distances. However, the author argues that, due to the homogenous approach of previous studies, the findings are likely to be skewed by a small number of lone actors who attacked iconic targets. When these cases are removed and symbolic

targets are considered, it is proposed that lone actors will travel further when it is necessary for them to do so, when the availability of relevant targets is limited.

Variations in distances for different target types reflected previous literature of traditional crimes (Hesseling, 1992; Fritzon, 2001; Santilla et al., 2008). Lone actors travelled much further for attacks where a symbolic building was present which is consistent with findings of traditional crimes that longer distances are travelled if the expected value of the outcome is higher (Pyl, 1974; Repetto, 1974; Baldwin and Bottoms, 1976; Rhodes and Conly, 1981; Hesseling, 1992; Tita and Griffiths, 2005), and further implies that some cost-benefit consideration is taken. These findings suggest that when considering any target that can be deemed as symbolic of the individual's grievance, a distinguishing factor in regards to spatial patterns is whether the target is a building or a person.

Over two thirds of attacks on iconic targets were perpetrated by individuals with single issue ideologies, demonstrating that attacks of this kind are more likely to be committed by members of this subgroup than Islamist and right-wing extremists, most likely due to the nature of their grievances. Single-issue actors committed less than a fifth of the attacks on symbolic targets. None of the right-wing cases studied in this chapter attacked iconic targets.

The significant differences concerning grievances provide a good starting point for further spatial analyses beyond this thesis that may be useful for practical interventions. No significant difference was found in distance travelled for Islamist and right wing lone actors, and the results suggest that their spatial decision making when selecting targets is similar to urban criminals. However single issue actors do not seem to be constrained by distance in the same way. They may have a limited choice set of targets to choose from due to the specific nature of their ideology. This demonstrates a necessity that, in any interdiction attempts, the ideology or grievance of the individual needs to be considered before attempting to narrow down possible targets.

The identifiable effects of distance for subgroups may be beneficial for preventative techniques, especially when coupled with leakage. In most lone

actor cases other individuals are aware of the individual's commitment to their extremist ideology, or intent to engage in a terrorism related activity (Gill et al., 2014). If an individual has been identified as likely to engage in an imminent attack this knowledge may be useful to narrow down potential targets. If an individual commits an attack but is not apprehended in the commission of their attack and manages to escape it could also be beneficial for post-event investigative techniques.

Consistent with previous research (Spaiij, 2010, Gruenewald et al., 2013; Asal et al., 2015), firearms seemed to be the weapon of choice for the lone actors studied in this chapter. Individuals travelled further when a bomb was used as their main weapon compared to firearms and bladed weapons. This may be reflective of capability, as 60% of lone actors who built a bomb had had face-to-face interactions with members of a wider network.

An underlying limitation of these analyses is the small sample. The cases used were not an extensive dataset of all lone actor attacks, as some had to be removed due to inaccurate or inconclusive information regarding home or attack locations. Therefore, it is inevitably subject to some bias. A larger sample would have been preferable; however, this was not possible without access to closed source data. This may mean that the sample used was not entirely representative and may limit the reliability of the results. A larger dataset would also have allowed for further disaggregation and additional statistical analyses to be run, for example to examine distances from places of work and education, and previous addresses. Only cases in the U.S. and Europe were used, therefore additional analyses need to be conducted to establish whether these findings have utility for other countries. When using Euclidean distance, there is also a small likelihood that distances could be over or under estimated, however the results are still useful when using this method (Rossmo, 2014).

Some scholars argue that a problem associated with this type of analysis is the *distance decay ecological fallacy,* whereby the aggregated distance decay function may conceal clustering and variation at the individual level (Townsley

and Sidebottom, 2010). If there is no individual distance decay, but the targets are dispersed randomly within the sample, it may incorrectly reveal a distance decay function (van Koppen and de Keijser, 1997) and therefore any inferences from the analyses may be inappropriate. To test for this, individual cases with more than one attack in a series were tested, for example John Ausonius and Johan Peter Mangs. A similar distance decay curve was apparent in their attack series.

3.6 Conclusion

Whilst the vast majority of the lone-actor terrorists travelled short distances, there are outliers worthy of discussion. Many of these outliers might simply be depicted as such because "residence" can be an imprecise indicator of awareness space. An individual's full awareness space is guided by other locations of their daily routine activities or past residences. Further quantitative analyses regarding the whole nodal network of an individual, including all possible nodes such as previous addresses, places of work and education, as well as their last known place of residence, were intended. However, this information could not be ascertained for every case, and therefore there was an insufficient amount of data to do so. Individuals who engage in urban crimes such as residential burglaries, robberies, thefts from vehicles and assaults are much more likely to offend in an area that they have previously lived, than in comparable areas where they have not resided (Bernasco and Kooistra, 2010; Bernaso 2010). Individuals have a range of routine activities, involving home, work, school, recreation etc, which increase their awareness space. This familiarity and increased knowledge of an area allows for a better evaluation of risks and minimises the effort of locating suitable targets.

The illustrative examples below highlight the importance of considering the whole awareness space of an individual. Even when individuals travel great distances, and the attacks are seemingly random, there is a strong likelihood of some

identifiable geographical connection between the actor and the target. Previous addresses, place of work/higher education need to be considered as well as the present.

Benjamin Nathaniel Smith

Benjamin Nathaniel Smith was a right-wing extremist who killed 2 individuals and injured 10 in his targeted attacks on ethnic minorities over a 3-day period in 1999. Smith began his attacks on Friday 2nd July, in the neighbourhoods surrounding his childhood home in Wilmette, where he had recently returned to live. These neighbourhoods, Rogers Park and Skokie, were predominantly populated by Orthodox Jews as well as large numbers of immigrants. The following day, on the penultimate day of his spree, attacks took place at the first university he attended (University of Illinois in Urbana) as well as two of the closest towns to the university by direct route. He fired twice at black men on streets of Springfield and a black minister was shot from Smith's car in Decatur. Finally, on the Sunday, he waited outside a Korean Methodist church near Indiana University in Bloomington, Indianapolis, before killing a graduate student as the congregation emerged. Smith had just finished his third year of college at Indiana University, and was living in student accommodation less than half a mile away from this campus until a few months before his attacks.

This case highlights the importance of considering all locations in the individual's awareness space, including previous addresses, places of work and education, as well as the areas surrounding their home (Bernasco and Kooistra, 2010; Bernaso 2010). This case also concurs with previous research on traditional crimes which suggests that an offender's first offence location will be closest to their home (Canter, 1994; Canter and Larkin, 1993; Warren, Reboussin, and Hazelwood, 1995).

Hesham Mohammed Hadayet

On 4th July, 2002, Hesham Mohammed Hadayet approached the Israeli airline El Al's ticket counter at Los Angeles International Airport (LAX) and started shooting at the passengers in the line, killing 2 Israeli nationals. It was concluded that this attack was due to his contempt of Israel's policies towards Palestinians and their occupation of the West Bank. Hadayet had intense anti-Israeli views that had developed over his time in the U.S. It is believed that his anger was only aimed at Israel, and not U.S. civilians. Abdallatef Aboulzahab, a former employee of Hadayet, stated:

"He blamed Israel for what was going on [in the Middle East]... He had nothing against Americans... He's not hateful for the American people on the street... He loved this country. He loved freedom of speech. He told me, 'I'd like to be a U.S. citizen.'"

On first examination, the location of this attack seems relatively random as Hadayet lived 40 miles away in Irvine, California. However, Hadayet was a taxi and limo driver who frequently served LAX and John Wayne airports, and so it is likely that he was aware of the El Al counter from previous trips. It can be inferred that he did not want to kill an American citizen and so LAX provided the closest location in his awareness space that could provide a large number of legitimate targets. Hadayet bypassed other busy ticket counters in the airport, so it can be inferred that his objective was not to target random civilians, as he could have attacked other counters more easily. As the flights dealt with by El Al are only in and out of Israel and is owned by the Israeli government it can be inferred that he made this choice as he specifically wanted to target Israelis.

Taimour Abdulwahab al-Abdaly

On 11th December, 2010, Taimour Abdulwahab al-Abdaly detonated two bombs in central Stockholm. When considering his last known address in Luton, al-

Abdaly travelled the furthest out of the European subgroup. However, prior to his attack he had recently returned to Sweden, visiting his parents in a small town called Tranas. The family had settled there as refugees after fleeing Iraq in 1992, when al-Abdaly was 11 years old. He lived there until 2001, before moving to the U.K. to study.

On the morning of 11th December, 2010, al-Abdaly left his parents' house and drove to Stockholm. It could be that Tranas, with a population of only 14,000 inhabitants, did not provide an adequate number of potential targets for the attack. A city with high urban density is much more attractive as a target, due to the increased number of potential victims and witnesses, as well as potential economic losses. There are two major cities close to Tranas: Stockholm and Gothenburg. Stockholm is the capital of Sweden so his attack would have more of an impact. This example further highlights the importance of the awareness space. It has been suggested that the bomb was intended to be triggered remotely, and that the explosives went off accidentally en-route to the intended target. The most likely target was the department store 'Ahlens', located at the end of the street. Ahlens is the largest department store in Stockholm, and as Al-Abdaly's attack took place just before Christmas it is likely that there were an increased number of people in the area at that time.

Collectively, the statistical analysis and illustrative examples suggest that distance can be put forward as a constraining factor that governs the selection of targets. Lone actor target selection is a result of a confluence of distance and appropriate targets, whereby a target will be chosen where it is a) in the individual's awareness space, b) within close proximity to the individual's home location and c) is relevant to the individual's ideology. This chapter has demonstrated that most lone actors will behave similarly to group terrorist actors and urban criminals. Therefore, it may be appropriate to consider any findings regarding the spatial decision making of group actors as applicable to lone actors. This chapter indicates that target selection is guided by an inherent logic, providing further support that environmental criminological methods are useful in understanding terrorism. The next chapter builds upon this line of argument by

analysing the spatial and temporal characteristics of a campaign of violence (as opposed to the sporadic and individual attacks characterised by lone-actor terrorists).

Chapter 4   Spatial and temporal patterns of contemporary violent dissident Republican incidents

4.1   Introduction

As well as the obvious threat from Islamist-inspired groups such as ISIS, one of the main contemporary concerns to U.K. national security is the threat from violent dissident Republicans (VDRs). VDRs reject the Northern Ireland peace process, want to demonstrate that the 1998 Good Friday Agreement has failed, and continue to fight for a united Ireland (Frampton, 2011, 2012; Bean, 2012; Evans and Tonge, 2012).

This conflict represents a relevant and growing terrorism threat (Morrison & Gill, 2016). Despite hopes that the Good Friday Agreement of 1998[1] represented an end to terrorism, dissident Republicans unhappy with the constitutional settlement continue their armed opposition with growing intensity. Speaking in 2010, Jonathan Evans, the Director General of MI5, admitted that the situation had been initially misjudged and that contrary to expectations, the preceding three years had seen a persistent rise in terrorist activity. The escalating nature of the threat was further echoed in the Strategic Defence and Security Review of 2010 (HM Government, 2010a: para.4.A.2), whilst the National Security Strategy of the same year classified the security situation as a tier-one priority risk (HM Government, 2010b: 27). Violent activity associated with dissident Republican groups continues to grow (Horgan & Morrison, 2011; Morrison & Horgan, 2016). The threat largely comes from two main groups: the Continuity IRA (CIRA) and the New IRA[14], as well as multiple smaller factions.

There is substantial support for the assertion that terrorism incidents are geographically concentrated (e.g. Townsley et al., 2008; Rossmo & Harries,

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[14] Óglaigh na hÉireann (ONH) were also particularly active until a ceasefire in January 2018.

2011; Braithwaite & Johnson, 2015; Tench et al., 2016). They typically cluster in space and time and occur in urban areas (Savitch and Ardashev, 2001; Nunn, 2007; Piegorsch et al., 2007). Spatial and temporal analyses can be effective in guiding the interventions and allocation of security resources needed to manage terrorist related incidents, which can improve the efficiency and productivity of police resources. However, there is still a distinct lack of research compared to the study of urban crimes. Most analyses regarding spatial and temporal patterns of group terrorism using finer scales of analysis have been focused on conflicts in Middle Eastern countries such as Israel, Pakistan, Afghanistan and Iraq (i.e. Kliot and Charney, 2006; Berrebi and Lakdawalla, 2007; Townsley et al., 2008; Siebeneck et al., 2009; Johnson and Braithwaite, 2009; O'Loughlin, Witmer and Linke, 2010; Zammit-Mangion et al., 2012). Little has been done to examine the threat from a sustained campaign of violence in Europe (with the exception of studies such as LaFree, 2012; Behlendorf et al., 2012).

This chapter seeks to expand on the existing literature relating to the geography of terrorism through an analysis of the spatial patterns of incidents involving VDRs in Belfast. Studies regarding VDR violence so far have largely been descriptive (see Tonge, 2004; Gilmore, 2009; White, 2010; Frampton, 2011; Taylor and Currie, 2011), except for a few notable examples (i.e. Morrison and Horgan, 2016). One of the main reasons for this is a distinct lack of data. The analyses in this chapter use parts of a unique detailed dataset of VDR violence created by Dr John Morrison (Royal Holloway University). In particular, this chapter conducts a Kaplan Meier hazard estimate and bivariate analyses of VDR incidents, as well as various spatial statistics comparing VDR bombings and hoaxes. The results demonstrate that the threat from VDR terrorism in the contemporary wave has been temporally and spatially concentrated.

4.2 Literature Review

This section discusses the elements that characterise the current terrorist threat in Northern Ireland as well as the existing research on spatial and temporal patterns of terrorist violence.

4.2.1 The current threat from VDRs

Prior to their final ceasefire on July 20, 1997, PIRA was the most prolific terrorist organisation operating within the region. Since then, the nationalist threat has instead emerged from multiple and distinct dissident Republican groups who reject the constitutional compromise accepted by PIRA leadership (Morrison, 2013). Collectively, dissident Republican organisations maintain that the only acceptable outcome is the complete reunification of the island of Ireland (Frampton, 2011; Evans and Tonge, 2012; Frampton, 2012). They also take the view that PIRA and its political wing, Sinn Fein, have become collaborators with the British state particularly through their endorsement of the Police Service of Northern Ireland (PSNI). Their principle strategy is to undermine the regime created by the Good Friday Agreement in a number of ways including: obstructing its institutions, seeking to increase British Army presence on the streets, offering alternative policing functions, seeking to recruit young members of the Catholic community, targeting Catholic members of the security and police forces and ultimately by precluding the establishment of a normalised existence. In essence, they hope to emphatically demonstrate that the agreement has failed (Frampton, 2011, 2012; Bean, 2012). Their use of violence therefore intends to act as both a "medium of mobilisation and propaganda against the state" (Bean, 2012, p.213).

However, lacking a comparable capability to PIRA (Frampton, 2012), they have been unable to undertake an intense and high profile campaign of violence. Instead, they use persistent and often low-level violence to shatter any illusion of peace and to occupy the resources of the police services, limiting their ability to fulfill their traditional role and consequently undermining their authority (Horgan and Morrison, 2011; Frampton, 2011; 2012). A core tactic of the current VDR campaign is the use of hoax devices, deliberately planted to disrupt civilians and occupy the security services' time. There has been a dramatic increase in the use of hoaxes during the contemporary wave of VDR violence (Horgan and Morrison, 2011), especially since 2009.

4.2.2 Spatial and temporal patterns of terrorist violence

Although far from comprehensive, there have been some applications of spatial, temporal and spatio-temporal analyses to terrorism. The main limitation of most research thus far is that the geographical areas they cover are too large to have meaningful practical implications for the prevention and disruption of terrorist acts. Early analyses, for example, focused on the spatial distribution of terrorism worldwide. Midlarsky et al. (1980) argued that terrorism has a contagion like effect, having physical contiguity between locations. However, recent research has demonstrated that worldwide contagious diffusion of terrorism is rare, and non-contagious increases are more common than contagious increases (LaFree, 2018).

Using 73,961 attacks in 206 countries and territories in the period 1970-2006, LaFree et al. (2010) demonstrated that terrorism is clustered on a global level, with just 32 countries accounting for more than three-quarters of all attacks during this period. The results confirmed that terrorist attacks were highly concentrated across specific countries and that these concentrations were stable over time. Gao et al. (2013) also found terrorist events to cluster on a global level, and proposed that periodic (daily or weekly) monitoring of terrorist events can aid in the early identification of terrorist outbreaks within countries. Braithwaite and Li (2007) studied transnational terrorism to identify hotspots at the country level. They found that, whilst not all countries within a hotspot experienced a large number of incidents, if a country was within a hotspot it was likely to experience an increase in number of terrorist incidents in the next period. Countries with higher populations unsurprisingly generate and experience more terrorism (Neumayer and Plumper, 2010). Terrorism is also more frequent in countries with low per capita income and richer countries are more attractive for international terrorists.

Terrorism is also clustered *within* countries. Savitch and Ardashev (2001) determined that terrorism is more common in cities than rural areas. Likewise, in their analyses of terrorist incidents in the US, both Nunn (2007) and Piegorsch et

al. (2007) concluded that terrorism clusters in urban areas. Python et al. (2016) used a Bayesian hierarchical framework to model the frequency of lethal attacks, as well as how lethal they were, through the integration of spatial and temporal dependencies. They found higher lethality for attacks close to large cities. When studying terrorist incidents in the U.S. from 1970-2004, Webb and Cutter (2009) found clear spatial and temporal patterns. Terrorism clustered in cities, with Washington D.C. and New York City accounting for a quarter of all activity within the U.S. throughout the period studied. Öcal and Yildirim (2010) used geographically weighted regressions to analyse variations in local activity of the Partiya Karekeren Kurdistan (PKK) in Turkey. This method uses a sequence of linear regressions to model relationships that vary over space and time. Distance based weightings were used to provide parameter estimates for each geographical location and variable and produce values for each region. They found considerable variation in the spatial distribution of terrorism throughout the country. Rehman (2015) found that terrorist attacks in Pakistan were spatially clustered, and that if an intervention was implemented in a district, it caused significant displacement of terrorist incidents to neighbouring districts.

As well as being spatially concentrated, like urban crime there is also an added temporal element in the clustering of terrorist attacks. Townsley et al. (2008) examined IED attacks in Iraq and found that they clustered in time and space. Johnson and Braithwaite's (2009) study of insurgent attacks found a similar result, with an increased period of risk for a further attack in the immediate vicinity of an initial attack of four to five weeks. Siebeneck et al. (2009) also identified spatial clustering in Iraq in the period 2004-2006. They identified variations in patterns of attack frequency and intensity (determined by the number of victims). As the number of attacks per month increased, the intensity of the attacks decreased. They also found a statistically significant decrease in frequency and intensity on or around Islamic holidays, and an increase on or around American holidays. Medina et al. (2011) expanded on this to examine the spatial, temporal and spatio-temporal patterns of incidents in Iraq from 2004-2009. They found

variations in attack patterns over time and that while frequency of attacks correlated with population variables, the intensities of the attacks did not.

Behlendorf et al. (2012) examined attacks by Euskadi ta Askatasuna (ETA) in Spain, as well as the Farabundo Marti National Liberation Front (FMLN) in El Salvador. Using a dataset of 4000 attacks, they identified spatio-temporal clustering, and found the two groups to exhibit substantial similarities. They call these clusters 'violent micro-cycles' (2012:50), and found that bombings and non-lethal attacks were more likely to be part of these micro-cycles than other types of attacks. Berrebi and Lakdawalla (2007) found the key determinants of spatial variation of risk of terrorist attacks in Israel to be proximity to operational bases and proximity to international borders. Areas near to international borders were twice as likely to be attacked than other areas. The risk of subsequent related incidents rose after an initial attack in Israel before returning to the baseline after approximately eight weeks. Marchione and Johnson (2013) found that following an initial incident of maritime piracy, the risk of a subsequent incident increased temporarily.

Elevation in risk extends beyond the location of the original offence (Farrell, 1995; Pease, 1998). Townsley et al. (2003), and Johnson and Bowers (2004), found that after a residence has experienced an initial burglary there is a temporary elevation in risk of a further burglary at the same premise or a neighbour's house. This is likely due to the number of potential opportunities identified by the offender when committing the initial offence. Similar patterns have been observed within and across different countries (Johnson et al., 2007) and across different crimes like assaults and robberies (Grubesic and Mack, 2008), shootings (Ratcliffe and Rengert, 2008), vehicle theft (Lockwood, 2012) and maritime piracy (Marchione and Johnson, 2013). Indeed, it has also been found in a terrorism context. For example, LaFree (2012) used logistic regression analyses to examine attacks by Euskadi ta Askatasuna (ETA) using data on previous incidents to aid in the prediction of the location of future attacks. They found differences in spatial patterns according to variations in the group's strategy. The locations of previous

incidents and the time elapsed since these incidents were significant predictors of subsequent attacks.

Mohler (2013) used a Hawkes-Cox process model to examine attacks in Northern Ireland. The identified pattern was like that of crime in Chicago, where approximately half of events could be attributed to contagion. A more recent study by Tench et al. (2016) also used a Hawkes process model to find that PIRA attacks between 1970 and 1998 were clustered in time. Again, changes in strategy were analogous with changes in the degree to which the attacks were clustered. There was also a relationship between PIRA's reaction to counter-terrorism events which resulted in fatalities. These findings lead to the first hypothesis:

H1: After an initial incident of VDR violence, the risk of a subsequent incident will increase and then decrease

The notion that crime is spatially clustered is widely supported in the criminological literature. Crimes are not equally or randomly distributed across locations (Block and Block, 1995), and occur when the following elements converge in space and time: when opportunities are presented to a motivated offender, through the availability of a suitable target, with the absence of a capable guardian (Cohen and Felson, 1979). These opportunities are identified within an offender's awareness space, and as demonstrated in previous research and the preceding chapter of this thesis, terrorist offenders tend to travel short distances to commit their offences. Within cities, crime is typically concentrated at a small number of locations, known as 'hotspots' (Eck et al., 2000; Bowers, 2014). These hotspots tend to be stable over time (Weisburd et al., 2004; Braga et al., 2010; Braga et al., 2011).

Studies concerning the concentration of urban crimes consistently demonstrate significant intra-neighbourhood variance. This information can be lost if neighbourhoods are only considered as wholes (Weisburd et al., 2004; 2009; Groff et al., 2010). For example, 'good' neighbourhoods (i.e. those with low levels of residential burglary overall) may have several 'bad' streets (those that

experience a high level of burglary) and vice versa. Weisburd et al. (2004) found that 4-5% of street segments in Seattle accounted for 50% of all crime. Around half of all street segments did not experience any crime. There have been a substantial amount of studies examining the spatial and temporal patterns of terrorism at country, region and city level. Analyses at finer levels of aggregation, such as administrative output areas and street segments, are now commonplace in the study of urban crime. However, a shift to micro-place study is yet to be extended to the study of terrorism. It can be proposed that micro-level analyses are the most effective unit to use to guide any policing measures that may be implemented in this context, and analyses at this level will therefore be used in this chapter. It is hypothesised:

H2: VDR incidents will be spatially clustered

One of the key limitations of previous terrorism research is that studies often treat different types of attacks homogenously. It is unlikely that different incident types will occur in the same place. Where bombings are concerned, there may be additional logistical elements involved in setting up and detonating viable devices that are not required for hoax devices. Ease of access and escape will be more important for viable devices, and it is likely that there is some awareness and consideration of associated risk. Gill, Marchment, Corner and Bouhana (2018) demonstrate that terrorist actors consider risk in a similar way to other types of offenders. Therefore, it is hypothesised:

H3: There will be differences in the locations of bombings and bomb hoaxes

Røislien and Røislien (2010) propose that target accessibility is a crucial component of target selection. This is a logical suggestion as areas that are more accessible and connected to other parts of the city, i.e. those that contain a major thoroughfare, are likely to be travelled on more often than other smaller streets, such as cul-de-sacs. Major roads facilitate travel around the city and as such an individual's familiarity with the area surrounding major thoroughfares is increased (Armitage, 2007). Therefore, it is likely that areas containing major roads will experience more attacks than those that are not, and it is hypothesised:

H4: VDR incidents will occur in close proximity to major roads

The stark residential segregation of Catholics and Protestants in Northern Ireland should also be considered. The separation of the two religious communities is a key characteristic of Northern Irish society that has helped in the understanding of many aspects of the conflict (Cairns, 1982; Hewstone et al., 2006). When optimal foraging theory is considered it is unlikely that members of VDR groups will regularly frequent Protestant areas (Hughes et al., 2008). These areas may not be in the offender's cognitive awareness space and as such they would have limited knowledge about the inhabitants (Brantingham and Brantingham, 1981) and physical infrastructure (Bernasco and Nieuwbeerta, 2005). Carter and Hill (1979) found that, in the case of extremely segregated cities, an individual's mental image of their city is often incomplete and strongly influenced by their racial background, due to the dangers of offending where they cannot blend in easily. Although this concept of 'standing out' in unknown territory is most obvious when considering race, the same effects may be reflected when considering religion. VDRs would be easily identifiable as the 'opposite side' (Gill, Horgan and Corner, 2017), and could be recognised as strangers to the area (Brown and Altman, 1981; Reynald et al., 2008; Bernasco and Block, 2009). Although it could be argued that a neighbourhood with a Protestant majority would be selected as a target area due to the availability of suitable targets it can be suggested that VDR members may avoid travelling through these neighbourhoods, to minimise the risk of detection and interception. Therefore, it is hypothesised:

H5: VDR incidents will be more likely to occur in areas with Catholic majority

4.3 Data and Analytical Strategy

The subsequent analyses will examine VDR incidents in Belfast, between January 2007 and 2016. First, a Kaplan-Meier hazard estimate will be employed to examine temporal variation in risk of a VDR incident. Leading on from this,

bivariate analyses will be performed to see if any factors of an initial attack increase the likelihood of the next attack occurring within a specified time period established through the hazard estimate. Finally, spatial analyses will be performed. The locations and patterns of bombings and bomb hoaxes will be compared.

4.3.1 Incident Data

The dataset of terrorist incidents was obtained from Dr John Morrison of Royal Holloway University, most of which was previously compiled for the 'Violent Dissident Republican Project' (Horgan and Morrison, 2011). It was created using open sources (e.g., media sources, governmental and non-governmental reports) and included VDR incidents in Northern Ireland from 1990 until the end of 2016. The dataset consisted of violent and non-violent incidents and included information regarding the date and time of the incident, the location of the incident, incident type, victim type, and so on. To maximise the utility for potential use by practitioners only attacks that took place during the third Contemporary wave (as defined by Horgan and Morrison) - January 2007 to December 2016 - were used for the analyses. There was a substantial increase in VDR violence during this time, especially after Sinn Fein's 2007 decision to support the PSNI.

4.3.2 Kaplan Meier Hazard Estimate

A Kaplan-Meier hazard estimate was performed to examine temporal variation in the risk of a subsequent incident after an initial incident. This method was used to enable comparisons to previous research on temporal risk variations for terrorist incidents (Berrebi and Lakdawalla, 2007; Johnson and Braithwaite, 2009). The procedure outlined by Berrebi and Lakdawalla (2007) was followed. After an initial incident (*i*), the time elapsed until the next incident (*i+1*) was calculated for each incident in the dataset. This is expressed algebraically as follows: there are *N* total incidents, *x(0)* of which experience a subsequent incident *(i+1)* on the same day, *x(1)* on the following day, *x(2)* 2 days later, and so on, until *x(t)*. The risk of a further incident on the same day is therefore calculated as: *x(0)/N*. The risk of an incident on the next day *(i+1)* is calculated

as $x(1)/(N-x(0))$, the risk of an incident two days later is $x(2)/(N-x(0)-x(1))$ and so on[15]. The hazard rate was computed and plotted against time to estimate the probability of a further incident occurring within Northern Ireland following an initial incident.

4.3.3 Bivariate Analyses

Following on from the hazard estimate, chi square tests of independence were run to see if any factors of an initial attack increased the likelihood of the next attack occurring within 4 days. The variables were coded as follows: A categorical variable was used to represent whether the time elapsed between incident i and the next event (incident $i+1$) was within 4 days. Binary indicator variables were used to indicate whether incident i resulted in a) casualties or b) fatalities; whether the incident involved the use of c) a viable explosive device; or d) a fake device; and e) whether the focus of the attack was civilians (as opposed to the security services).

4.3.4 Spatial Statistics

Geographical Data and Units of Analysis

Belfast was a logical choice for the spatial analyses as it had experienced the most VDR incidents during this time (around one third of all incidents in Northern Ireland). It is the capital and largest city of Northern Ireland and is on the flood plain of the River Lagan. The spatial analyses were focused on two incident types: bombings and hoaxes. The dataset for these analyses consisted of all cases of bombings and hoaxes where the street address for the incident was

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[15] The smallest unit of time available for all events was the date on which the incident occurred. This excludes the possibility of determining the ordering of events when multiple incidents took place on the same day. However, this was not problematic in relation to the present analysis as it was necessary only to measure the elapsed time between incidents. For example, where three incidents occurred on the same date, two of these can safely be considered to have preceded at least one incident on the same day. In each case the elapsed time would be zero days.

known. All cases that were not located in Belfast had been removed from the dataset. The latitude and longitude coordinates were determined for the street of each incident. If the street address of the incident was not known, the case was removed from the dataset (n=3)[16]. To conduct the analyses within a Geographic Information System (GIS) it was necessary to geocode all incidents in the dataset and convert into a point shapefile. These were then appended to ward, small area (SA) and street level in ArcMap. CrimeStatIV was used to calculate the nearest neighbour indexes. All other spatial statistics were conducted in ArcMap.

'Small area' and street level analyses were conducted. Since 2011, Northern Ireland has been divided into 4537 small areas (SAs) which are currently the smallest geographical unit above streets and will be used for most of the spatial statistics in this chapter. It was decided that this was the best unit to use as they are not only the smallest level above streets, but they were designed specifically for statistical purposes and follow physical features of the environment such as roads and rivers (NISRA, 2011). The shapefile for SAs was obtained from OpenDataNI, and the shapefile for streets was obtained from OpenStreetMap.

Small Area Characteristics

Major thoroughfares (A-roads) were identified using the Ordnance Survey of Northern Ireland. Religious data was taken from the 2011 census, obtained from the Northern Ireland Research and Statistics Agency (NISRA).

Nearest Neighbour Analyses

A Nearest Neighbour Index (Nni) was calculated for each type of incident in CrimeStatIV. This method was used as a starting point to determine whether each type of incident was clustered or dispersed more than would be expected by chance, and to what degree. The nearest neighbour index is the ratio of the

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[16] it was necessary to remove 2 bombings and 1 hoax due to missing geographical information).

observed nearest neighbour distance to the mean random distance, and is calculated as follows:

$$Nearest\ Neighbour\ Index = \frac{Average\ nearest\ neighbour}{Expected\ average\ nearest\ neighbour}$$

Where:

$$Average\ Nearest\ Neighbour = \frac{Distance}{Number\ of\ events}$$

And:

$$Expected\ Average\ Nearest\ Neighbour = \frac{1}{2}\sqrt{\frac{Area}{Number\ of\ points}}$$

If the observed average distance is like the mean random distance, then the ratio will be close to 1. If the observed average distance is smaller than the mean random distance then the nearest neighbour index will be less than 1, indicative of clustering. If the observed average distance is greater than the mean random (expected) distance, then the index will be greater than 1, indicative of dispersion (CrimeStat Manual, Chapter 5). The significance test for the nearest neighbour index determines whether the average nearest neighbour distance is significantly different than what would be expected by chance.

Thematic Mapping

Thematic mapping visualises spatial variations across defined geographical units, such as census boundaries. In this case, frequency of incidents were divided into bombings and bomb hoaxes, and aggregated to small areas and streets. These counts by geographic area were used to create thematic maps to display the distribution of incidents across Belfast.

Although thematic mapping is a useful tool in exploratory analysis, it is subject to limitations such as the ecological fallacy[17] and any analyses using geographical

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[17] Where an inference is made about an individual based on aggregate data for a group. Ecological fallacy effects are endemic when using areal units such as district boundaries, as they

boundaries defined by census administration are subject to the modifiable area unit problem (MAUP) (Openshaw, 1984).[18] Using different boundaries can result in significantly different maps. Therefore, several types of spatial statistics were employed to gain a better understanding of the data.

Local Indicators of Spatial Autocorrelation (LISA): Local Moran's I

Local Moran's I (Anselin, 1995) is a measure of spatial autocorrelation or dependency: the degree to which the value of a variable at one location is influenced by neighbouring locations, i.e. the clustering of 'like' values. When used for operational purposes, Local Morans I is preferred to other methods of hotspot analysis (i.e. the Getis-Ord Gi* statistic) because it can identify statistically significant clusters of neighbouring features with similar values, as well as outliers.

Spatial autocorrelation is important as it provides information on the degree to which the locations of events are related to each other (Levine, 2013). Tobler (1970: 236) posited that "everything is related to everything else, but near things are more related than distant things", therefore places closer together are more likely to have similar values. Whereas the Getis-Ord Gi* statistic can ascertain where features with either high or low values cluster (surrounded by other similarly valued features), Local Morans I can distinguish between statistically significant clusters of high values surrounded by high values (HH), low values surrounded by low values (LL), high values surrounded by low values (HL), and low values surrounded by high values (LH).

For this chapter, each pair (L, N) of local (L) and neighbouring (N) SAs consist of the standardised level of incidents in each spatial unit. These are standardised relative to their respective mean and standard deviation across the spatial units.

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are typically defined in an arbitrary manner and are rarely natural or meaningful (Openshaw, 1982).

[18] "The results of any geographic aggregation process, such as the count of crimes within a set of geographic boundaries, may be as much a function of the size, shape and orientation of the geographic areas as it is of the spatial distribution of the crime data" (Chainey and Ratcliffe, 2005: 151-152).

Neighbouring SAs are those that are adjacent to the local SA and share a common border. Each SA is classified as having either low (L) or high (H) frequency, relative to the distribution of local and neighbour values across the whole area. If the two SAs both have values above their respective means then they will be classified as high-high (HH). If they are below their means then they will be classified as low-low (LL). If the local and neighbouring SA differ then they will be classified as high-low (HL) or low-high (LH).

Kernel Density Estimation

A Kernel Density Estimation (KDE) of each incident type was produced to identify hotspots within the city. This method was used as it is not constrained by boundaries and allows incidents to be mapped over a continuous surface, so it is easier to interpret where incidents are clustered. KDE calculates a magnitude-per-unit area from point features using a kernel function to fit a smoothly tapered surface to each point. The individual density surfaces are integrated in order to generate a continuous density surface over the entire area. Quartic function of interpolation was used as it weighs near points more than far points and so the risk of repeat and near repeat victimisation is considered according to its distance decay (Johnson et al., 2009; Levine, 2013). This function also has high predictive accuracy and distinguishes peaks within the data (as opposed to a more generalised smoothing of the surface) (Drawve, 2016). Cell size resolution was set according to the division of the shorter side of the minimum bounding rectangle[19] by 150 (Ratcliffe, 2004). Bandwidth was selected by multiplying the median nearest neighbour distance by 6 (Brimicombe, 2004). The bandwidth determines the number of observations (incidents) around each point and controls the distance decay in weighting function. The larger the distance between any incident and the location of estimating the density, the less weight is assigned. This non-parametric approach has been widely applied to

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[19] The shortest of the two extents between the maximum *x* and minimum x, and maximum *y* and minimum y

characterise spatial crime data as it is has high predictive accuracy (Chainey et al., 2008).

4.4 Results

4.4.1 Descriptive Statistics

Between 1st January 2007 and 31st December 2016 Northern Ireland experienced 920 VDR related incidents, including bombings; bomb hoaxes; shootings; assaults; arsons; hijackings; kidnappings; protests; and riots. Of these, 61% occurred in Belfast or Londonderry. The final working dataset for Belfast consisted of 293 incidents where the precise location was known. This included 99 bombings and 89 bomb hoaxes for the spatial statistics.

4.4.2 Kaplan-Meier Hazard Estimate

The results of the Kaplan-Meier hazard estimate demonstrate that the risk of another attack is highest the day after an initial incident, before steadily declining, thus supporting hypothesis one (see figure 4.1). Around 23% of incidents were likely to be followed by another incident the next day. The risk of a subsequent incident on the same day is also high, with around 20% of succeeding incidents likely to be experienced the same day as an initial incident. After the second day, the hazard rate begins to decline quite substantially, reaching a low level at 4 days, and 0.01% at around 10 days. Around 12 days after an initial incident there is a slightly elevated level of risk, rising to 0.05 and then declining to 0.007%. After 3 weeks, the chance of a subsequent incident levels off at 0.001%.

*Figure 4.1. Hazard estimate of VDR incident risk within Northern Ireland following
an initial incident*
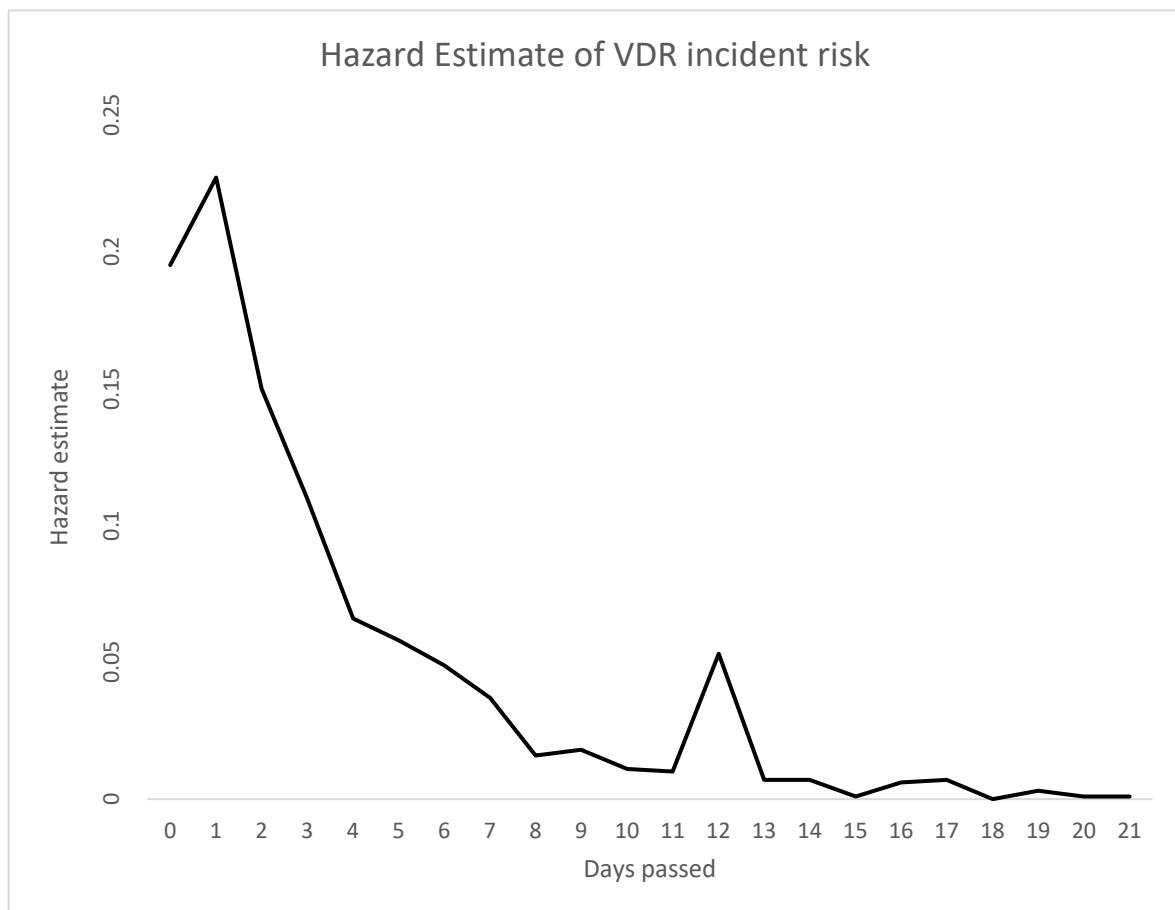
4.4.3   Bivariate Analyses

Chi square tests of independence were conducted to see if any attributes of an
initial VDR incident in Northern Ireland (fatalities; injuries; use of a viable
explosive device; use of a fake device; aimed at civilians) were associated with a
subsequent incident occurring after an initial incident within 4 days. Two variables
demonstrated significant results. If the initial incident resulted in injuries $\chi(1) =$
12.810, $p <.001$, or involved the use of a viable explosive device $\chi(1) = 4.081$, p
$=.043$, a subsequent incident was less likely within 4 days.

4.4.4 Spatial Statistics

Taken together, the analyses presented in this section indicate that VDR incidents were spatially clustered during the period studied. It can be concluded that future VDR incidents are not likely to be randomly distributed, and that different incident types yield different spatial patterns. The general pattern was that most of the city was free from incidents, reinforcing previous findings of urban crime that most places experience little or no crime.

Nearest Neighbour Analyses

The nearest neighbour index for bombings indicated that this type of incident was significantly spatially clustered: Nni = 0.62, (p<.001), providing further support for hypothesis one. Hoaxes were also significantly spatially clustered, to a greater extent than bombings: Nni = 0.37, (p<.001).

Thematic Mapping

Just 8.5% (n=74) of SAs (see figures 4.2, 4.3 4.4 and 4.5) and 1.2% (n=97) of streets experienced a bombing. The highest frequency of bombings occurred in a residential area to the west of the city centre. 7.77% (n=68) of SAs (see figures 4 and 5) and 1.03% of streets (n=82) experienced a hoax. Most hoaxes occurred in the city centre.

Figure 4.2. Thematic map of bombings in Belfast, January 2007 – December 2016 at small area level
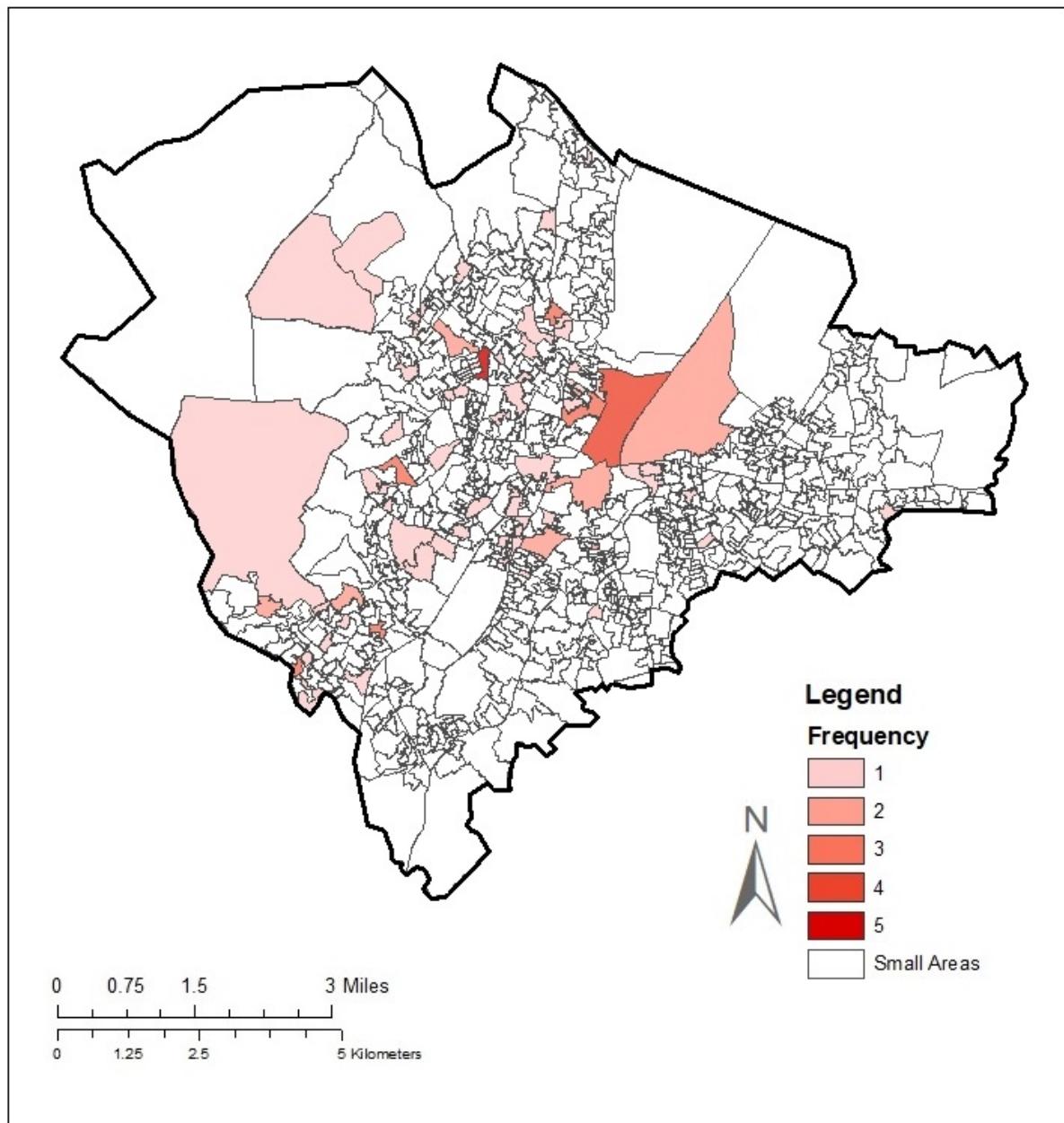
Figure 4.3. Thematic map of hoaxes in Belfast, January 2007 – December 2016 at small area level
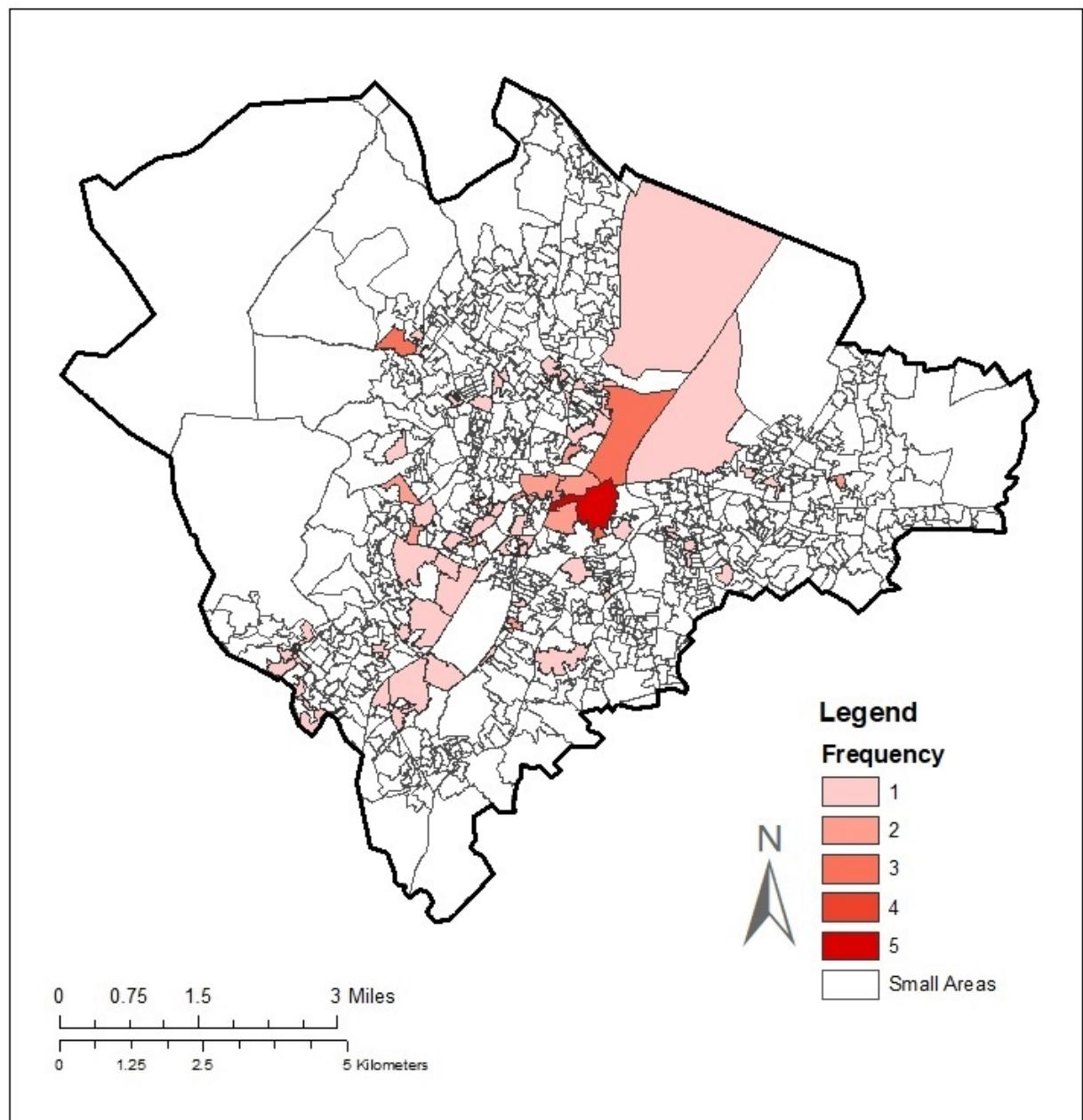
Figure 4.4. Thematic map of bombings in Belfast, January 2007 – December 2016 at small area level (zoom)
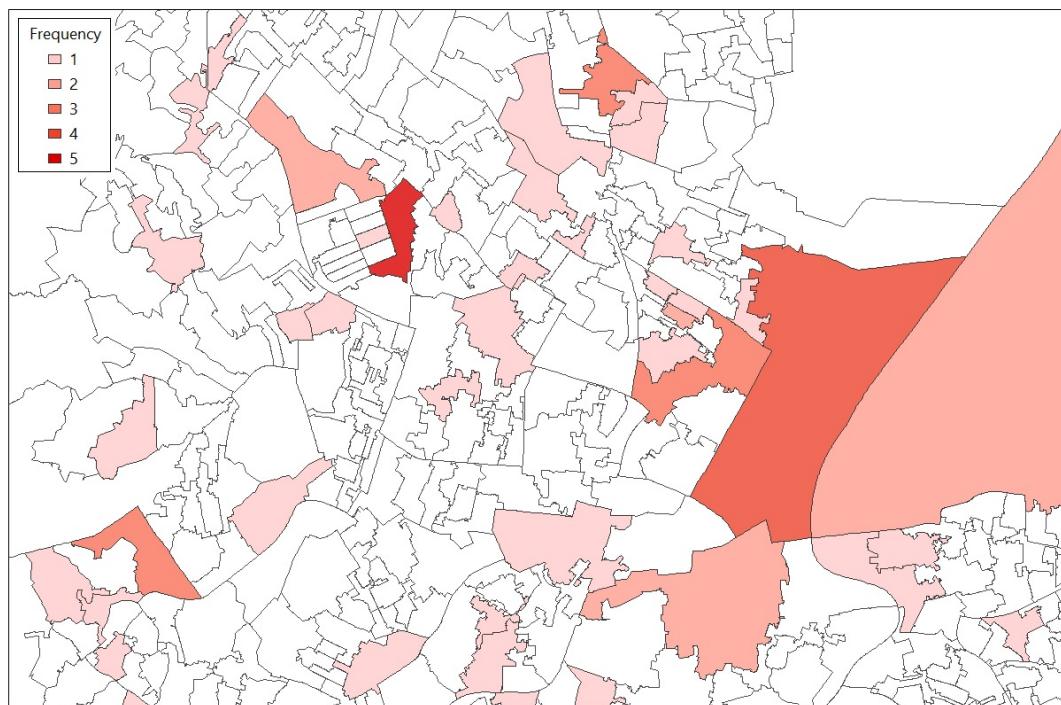
Figure 4.5. Thematic map of hoaxes in Belfast, January 2007 – December 2016 at small area level (zoom)
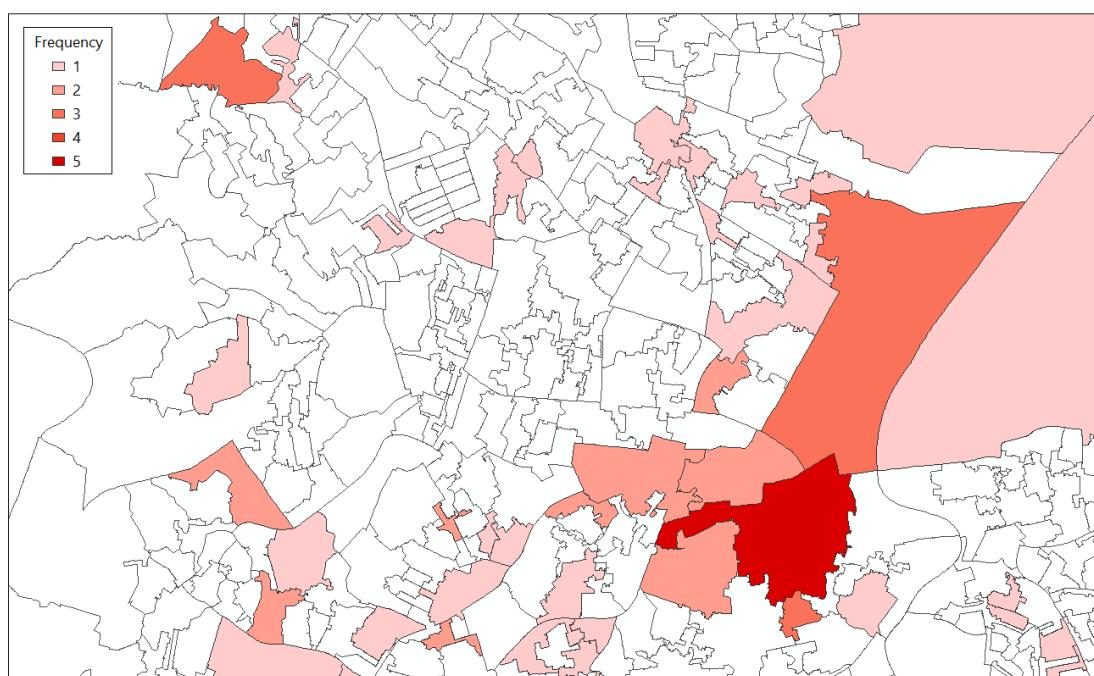
There was high street by street variation in SAs with high frequencies, with a small number of streets accounting for the total high count. Examples are provided in figures 4 and 5. This highlights how thematic maps at SA level can be misleading, as they highlight the whole of these areas as having a high frequency of incidents, and suggests that the incidents were uniformly distributed throughout. However, when looking at the street level, it is evident that they occurred on just a few streets. This reinforces the need for spatial analyses regarding terrorism to move towards smaller levels of analysis that are now common within the study of urban crimes.

Figure 4.6. Thematic map of bombings in Belfast, January 2007 – December 2016 at SA and street level
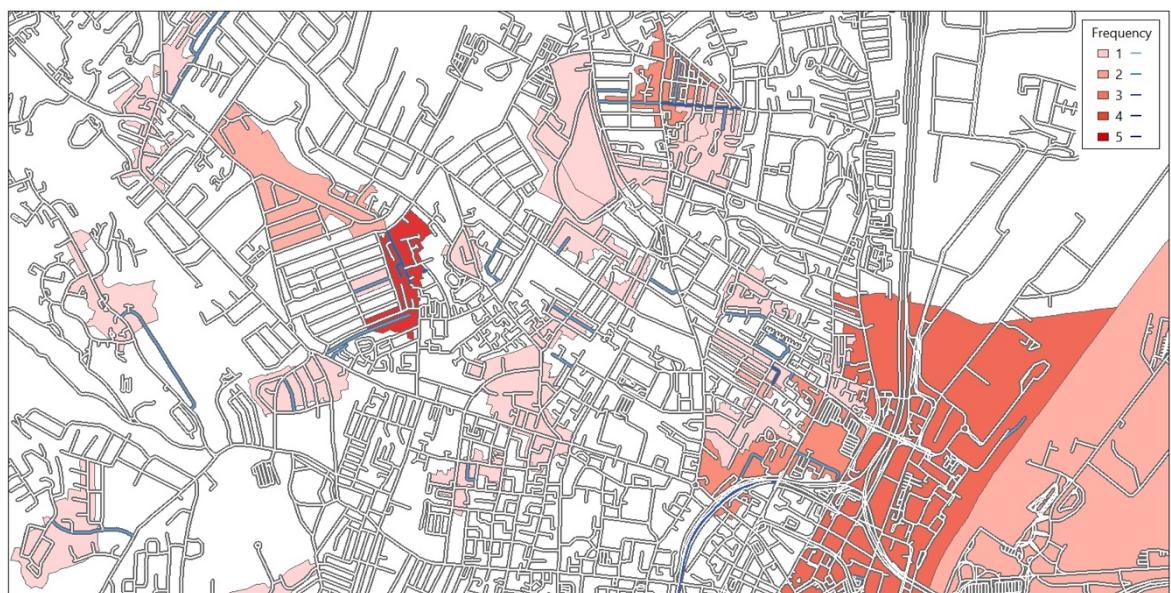
Figure 4.7. Thematic map of hoaxes in Belfast, January 2007 – December 2016 at street level
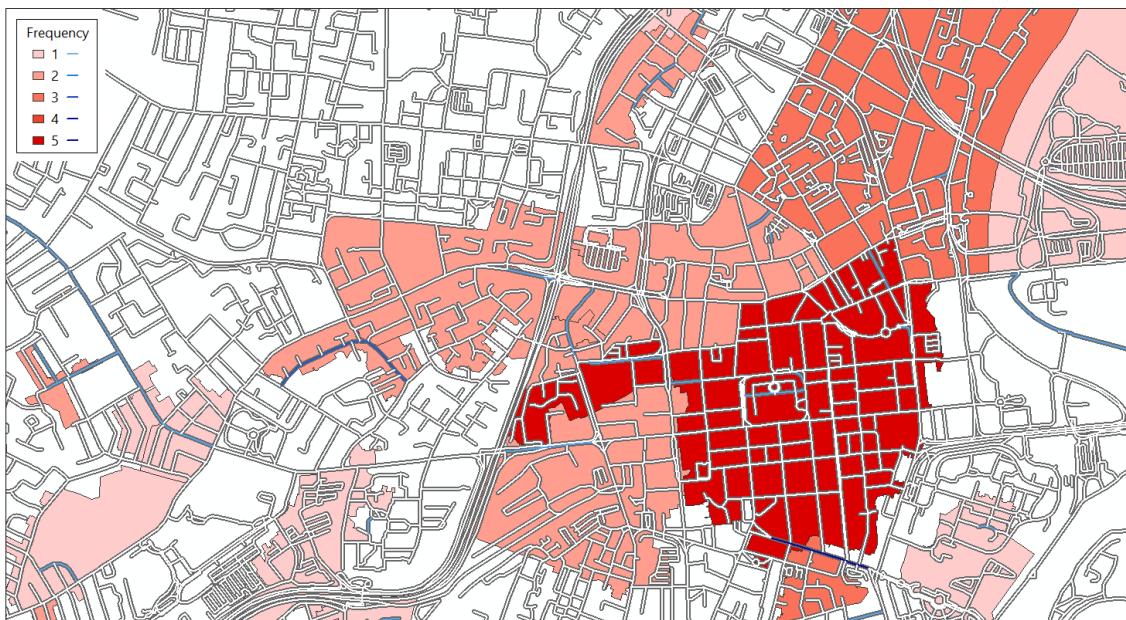
Local Moran's I

Most SAs were non-significant for both types of incident, meaning that the count of incidents was not significantly correlated with the count of incidents in surrounding SAs, either positively or negatively. The remaining SAs were classified into four categories, all of which indicate significant local spatial autocorrelation.

For bombings (see figure 6), 12 SAs were identified as high-high clusters, indicative of significant positive spatial autocorrelation, meaning each of these SAs had a high frequency of bombings and were surrounded by other areas with high levels. Several high-low (n=24) and low-high (n=80) outliers were identified, representative of negative spatial autocorrelation. No low-Low clusters were identified.

Most SAs for hoaxes (see figure 7) were also non-significant. 11 SAs were identified as high-high clusters, indicative of significant positive spatial autocorrelation. Several high-low (n=18) and low-high (n=86) outliers were identified, representative of negative spatial autocorrelation. One low-low cluster was identified.

Figure 4.8. Local Moran's I of bombings in Belfast, January 2007 – December 2016
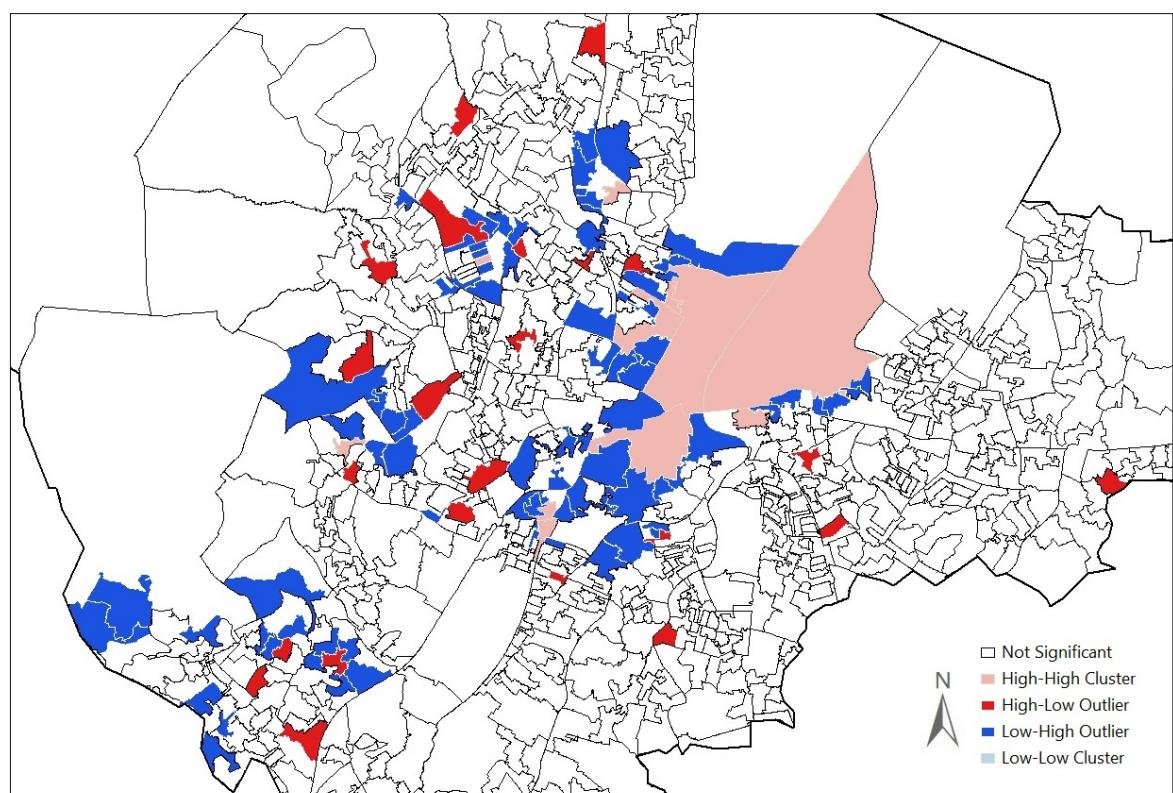
Figure 4.9. Local Moran's I of hoaxes in Belfast, January 2007 – December 2016
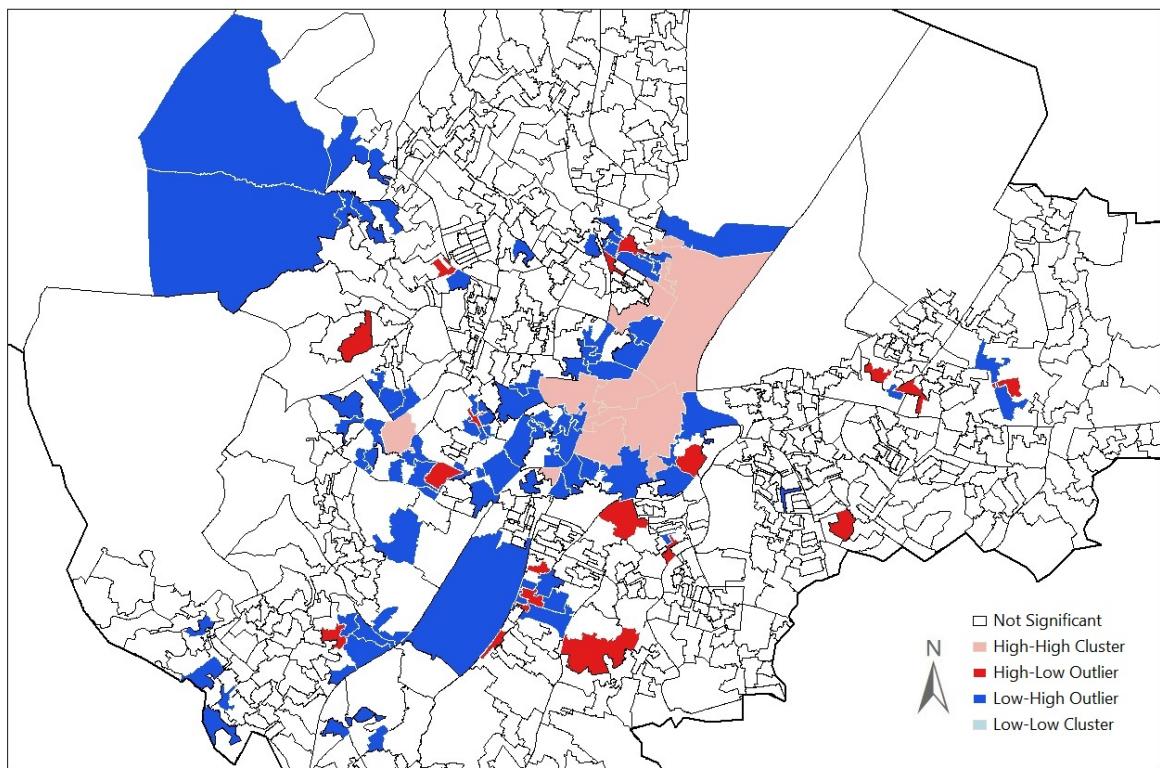
Kernel Density Estimation (KDE)

Data between January 2007 and December 2013 were used for the KDEs. The KDE for bombings identified three main hotspots. Two were to the south of the city centre, and the third was to the west. For hoaxes, two main hotspots were identified. The first was in the city centre, and the second was to the south west of the first.

Figure 4.10. KDEs of bombings in Belfast, January 2007 – December 2013
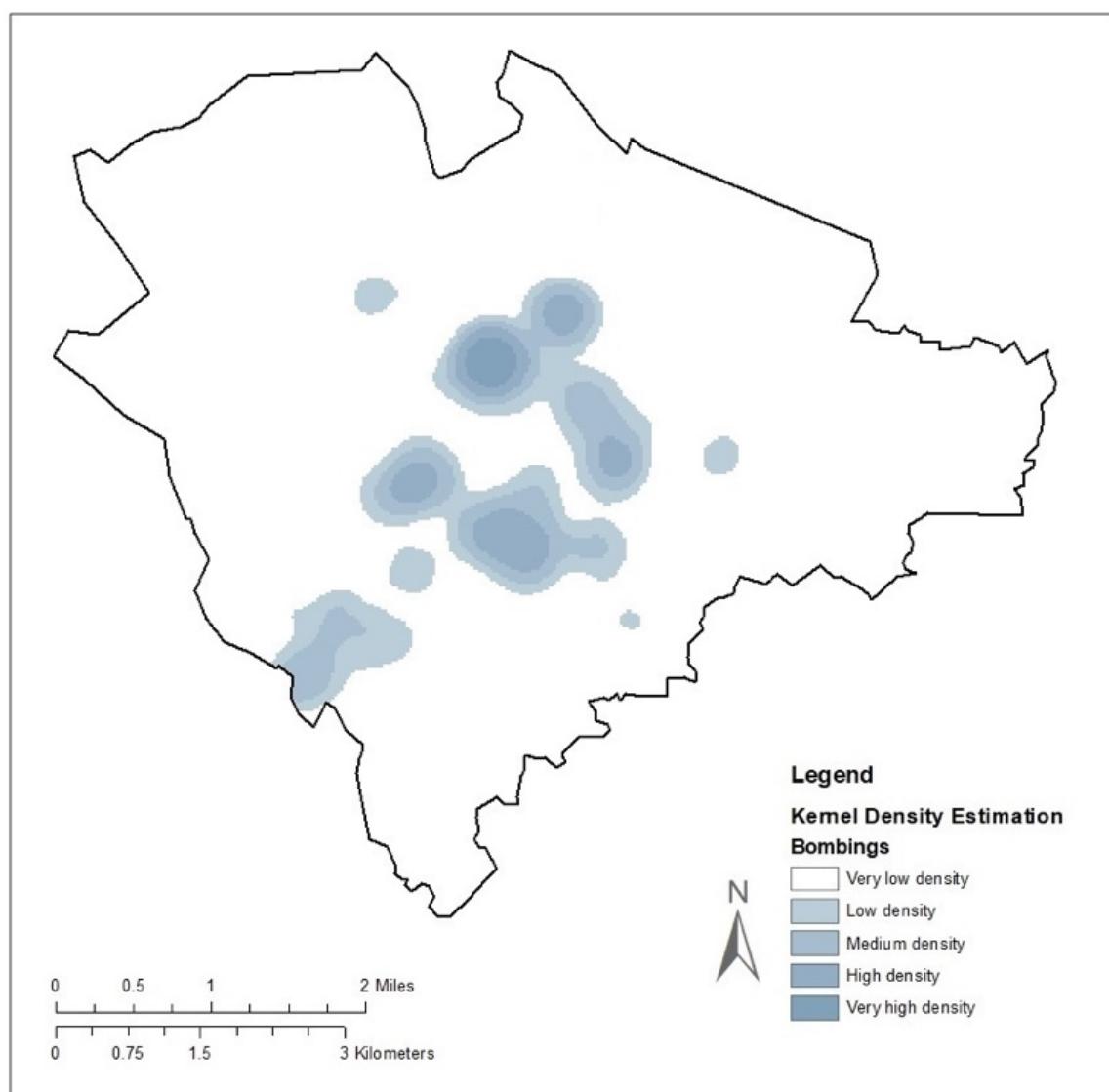
Figure 4.11. KDEs of bomb hoaxes in Belfast, January 2007 – December 2013
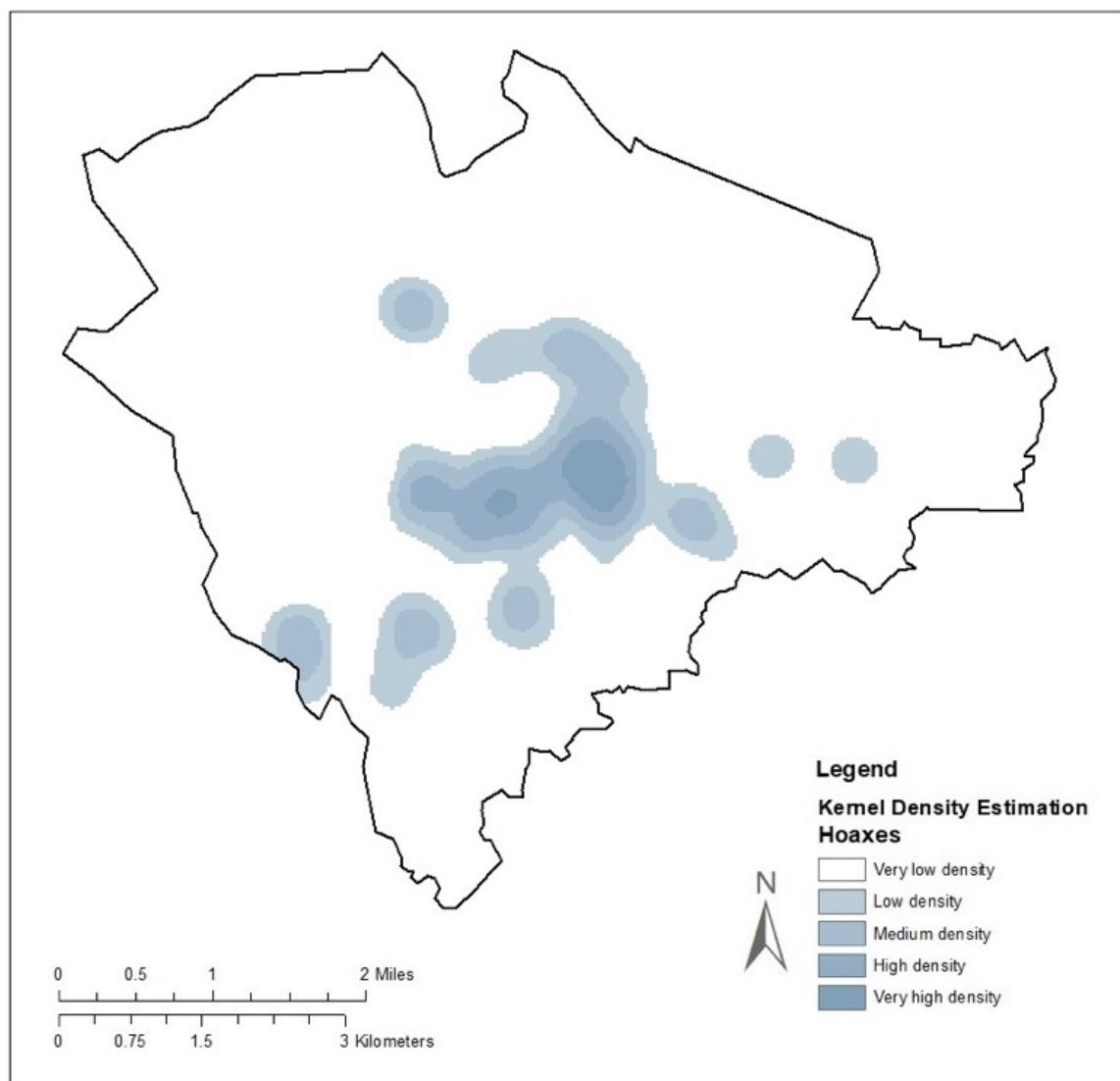
Predictive accuracy of KDE

Due to a limited amount of data any assessment of predictive accuracy of methods used in this thesis is reliant on descriptive statistics. Incidents occurring between January 2014 and December 2017 were plotted to see if KDE could be a useful tool in identifying areas at future risk of a VDR incidents (see figure 9).

Several post-2013 bombings occurred areas with low-medium density. Only 3 bombings occurred in high or very high density areas (see table 1). Most hoaxes occurred in high or medium density areas.

Figure 4.12. Locations of 2014-2017 bombings
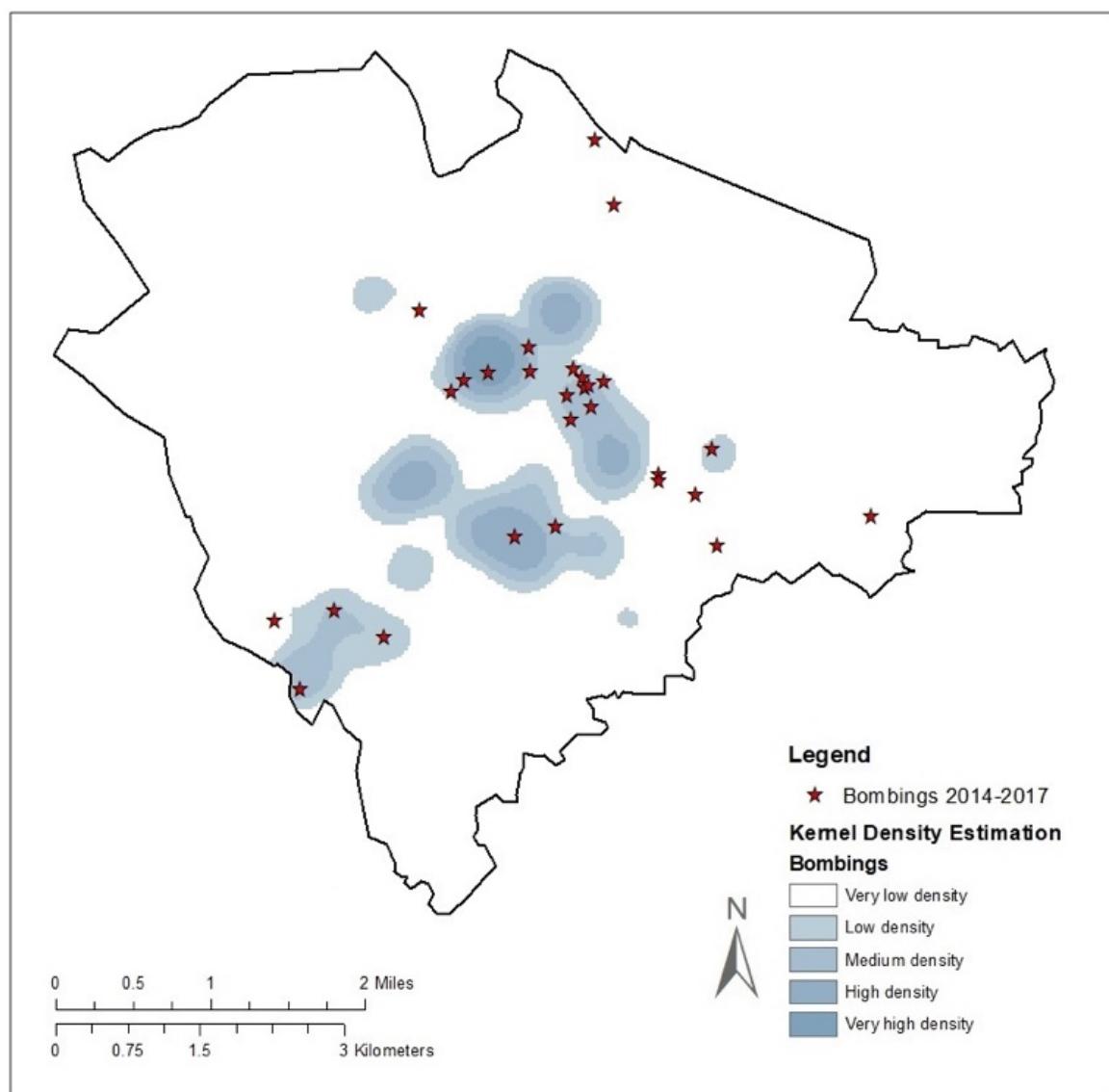
Figure 4.13. Locations of 2014-2017 hoaxes
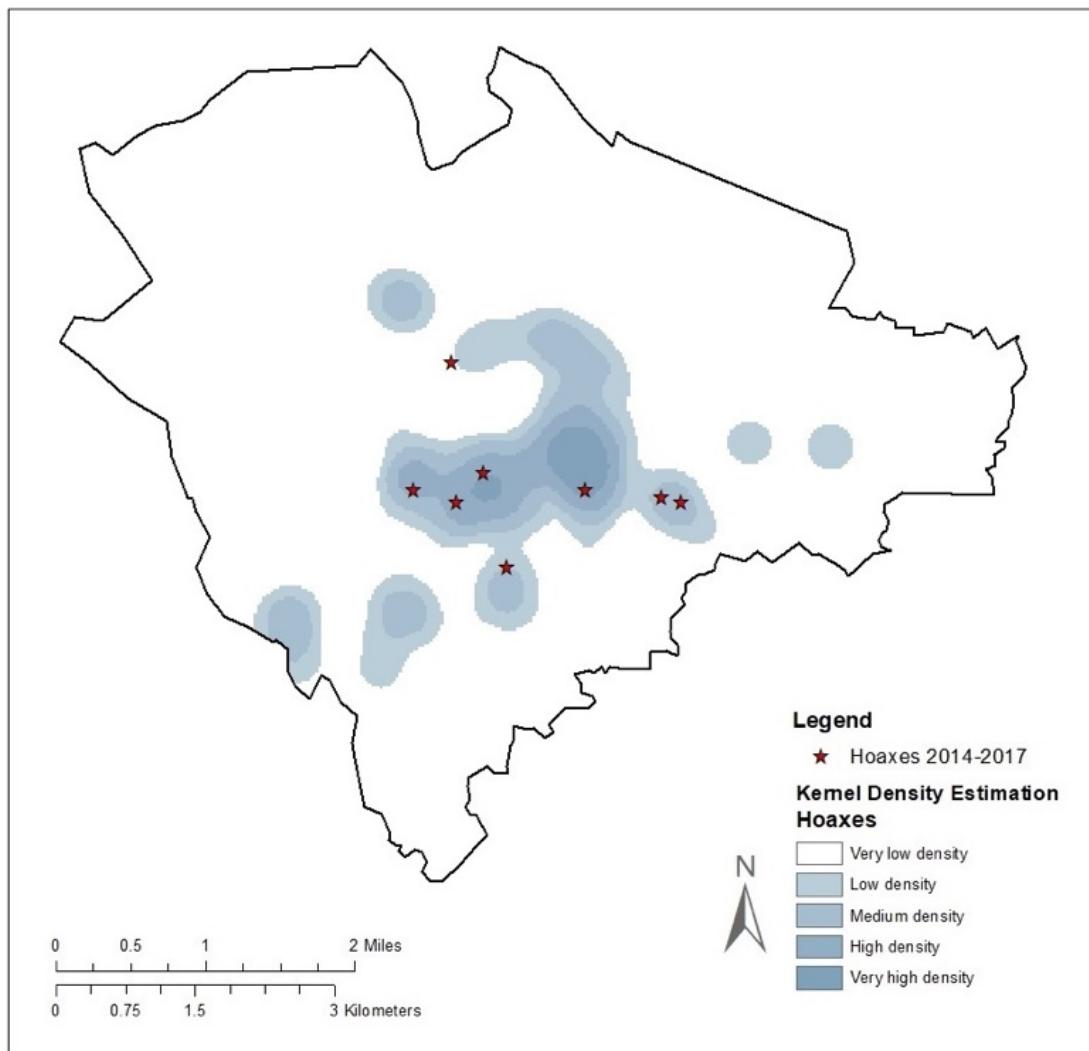
Table 4.1. Locations of 2014-2017 bombings and bomb hoaxes by to density level

Density Level	Frequency	
	Bombings	Bomb Hoaxes
Very low density	9	1
Low density	7	1
Medium density	9	2
High density	2	4
Very high density	1	1

Proximity to major thoroughfares

SAs that experienced VDR incidents were more likely to be in closer proximity to major roads (A-roads). A Mann-Whitney U test revealed significant differences in distance to a major road for SAs that experienced bombings (mean rank = 368.75) and those that didn't (mean rank = 444.4), (U = 24512.5 (z = -2.464), p = 0.014) and SAs that experienced hoaxes (mean rank = 354.99) and those that didn't (mean rank = 445), (U = 21793 (z = -2.820), p = 0.005. These analyses were conducted using the distance between the geometric centroid (the centre point) of each SA and a polyline file of the major roads.

Religious Segregation

Most areas that experienced several VDR incidents had a Catholic majority. Spearman's correlations were run at SA level to determine the relationship between the number of attacks and percentages of Catholic and Protestant residents.

There were weak, positive correlations between percentage of Catholic residents and all incidents (r = .282, p <.001); bombings (r =.125 p <.001) and hoaxes (r =.145 p <.001); thus supporting hypothesis 5. Weak negative correlations were found between percentage of Protestant residents and all incidents (r=-.274 p<.001); bombings (r=-.116 p<.001); hoaxes (r=-.141 p<.001).

4.5   Discussion

The aim of this chapter was to identify spatial and temporal patterns of incidents by VDRs in Northern Ireland, and establish if the risk of a subsequent incident is extended beyond an initial incident. The findings shed some light on the current threat to U.K. national security and are a step forward in establishing an effective police response to the problem of VDR terrorism in Northern Ireland and within Belfast. The findings reinforce the importance of considering information about the timing and location of previous attacks to quantify the risk of subsequent

attacks. Within Northern Ireland, the incidents were spatially clustered and mainly concentrated in two cities. The most common types of incidents were bombings, bomb hoaxes and punishment attacks.

In line with hypothesis one, the Kaplan-Meier hazard estimate revealed the risk of a subsequent incident to be highest the day after an initial incident before steadily declining. The next highest level of risk was the same day. After the second day, the hazard rate begins to decline quite substantially, reaching a lower level at 4 days and reaching a plateau after 3 weeks. If an attack has taken place, then a subsequent attack is high within this period. This finding is in line with previous studies which found the risk of a subsequent incident to be elevated after an initial incident (Berrebi and Lakdawalla, 2007; Johnson and Braithwaite, 2009; Marchione and Johnson, 2013), however the period of elevated risk is quite different. Johnson and Braithwaite (2009) found an increased level of risk for four to five weeks, and Berrebi and Lakdawalla (2007) found an elevated risk for eight weeks. This may be a function of the capability of the group or may be reflective of the types of incidents carried out. Different conflicts present different patterns and therefore it should not be assumed that the results of this hazard estimate will transfer across different territories.

The chi square analyses revealed that if an attack resulted in injuries, it was less likely to be followed by a subsequent attack within 4 days. An incident resulting in injuries could be inferred as a 'successful' incident. An attack was also less likely within 4 days if a viable explosive device was used. The use of a viable device is likely to involve more planning than a hoax device, and greater expertise and resources are needed to create the device. Future research could examine the interactions between security incidents and police responses and counter terrorism strategies. Unfortunately it was not possible to include this in the analyses. It could be that an increased security response following an incident may have deterred VDRs from committing further attacks within a close time period. The results from the Kaplan-Meier indicate that increased patrols following an initial attack are warranted. It would have been preferable to analyse findings with a comparison of locations pre and post a specific intervention. This

data was unavailable for the current study, but there may be a possibility to include it in future research.

Consistent with hypothesis two, both types of attacks were spatially clustered. The analyses revealed non-random distribution within the city and indicated that incidents were geographically concentrated in specific areas. Large areas of the city experienced no or very few attacks. The east side of the city experienced few attacks when compared to the west. The area between the Crumlin and Falls roads experienced very few attacks, as did the outer areas of the city. The nearest neighbour analyses revealed that both incident types were significantly spatially clustered. The results are consistent with findings for insurgent activity in countries such as Iraq and Palestine (Berrebi and Lakdawalla, 2007; Johnson and Braithwaite, 2009). Most streets in the city experienced no attacks at all during the period studied. This finding is consistent with the wider criminological literature and the pareto principle.

High degree of variability was found between and within SAs. This highlights the importance of using micro level geographical units for the analysis of terrorist threats. Some of the analyses in this study are subject to the modifiable area unit problem (MAUP) (Openshaw, 1984), as they required the data to be spatially aggregated to areas as geographical boundaries defined by census administration were used (small areas and streets). As Chainey and Ratcliffe (2005, p. 151-152) effectively describe, "the results of any geographic aggregation process, such as the count of crimes within a set of geographic boundaries, may be as much a function of the size, shape and orientation of the geographic areas as it is of the spatial distribution of the crime data". Using different boundaries can result in significantly different maps. There are numerous alternative ways that the data could have been aggregated, all of which may have had different outcomes. This is a potential source of error that can affect outcomes of spatially aggregated data. However, analyses at street level minimise the aggregation and therefore limit the risk of ecological fallacy (Brantingham et al., 1976). Spatial heterogeneity (uneven distribution of population and environmental factors), that is often observed when using large

areal units, is also reduced when using street segment level of analysis (Smith et al., 2000). This level is also the most useful for practical interventions and policy implications.

The use of the KDEs overcame these problems, as this method smooths the surface and is not constrained by boundaries. However, KDE is also subject to some limitations. As it is a smoothing technique some of the surface may cover areas where no incidents have occurred, and therefore exaggerate the extent of the problem. The interpretation of the KDE can be also subjective, as the risk density thresholds can be changed. KDE also ignores the influence of the street network on the locations of incidents. This means any features of the street network that may be factors in target selection are disregarded. This highlights the need for a combined approach when analysing VDR incidents in Northern Ireland.

The Local Moran's I analyses were used to enhance the understanding of the underlying spatial patterns by measuring the extent of similarity or dissimilarity of VDR incidents across neighbouring spatial units. They identified several clusters of neighbours with high-high values. These statistically significant clusters are indicative of underlying favourable conditions that extend beyond a single spatial unit (SA). However, numerous outliers for both types of incident were also identified, in many different areas of the city. There may be different factors in these neighbouring areas that create favourable or disadvantageous conditions for these incidents. Further analyses should be conducted to identify situational factors of these areas that may be correlated with bombings and hoaxes.

Consistent with hypothesis three, differences in locations were found for bombings and bomb hoaxes, as visualised in the thematic maps at small area and street level. The highest frequency of bombings was in a residential area whereas the highest frequency of hoaxes was in the city centre. This demonstrates that there may be different factors at play when distinguishing targets for different types of attacks and provides further support for the disaggregation of incidents when conducting analyses of terrorist target selection.

In line with hypothesis four, VDR incidents were more likely to occur in areas in closer proximity to major roads. As mentioned in the literature review of this chapter, crime pattern theory suggests that streets that are more likely to be travelled upon may be more likely to experience incidents. Future research could build on this by applying graph theoretical measures to identify risky streets through an analysis of the street network. Some sections of streets are more likely to feature in routes than others. The types of streets least likely to experience urban crimes are cul-de-sacs and private roads (Johnson and Bowers, 2010; 2013), even when accounting for factors such as levels of deprivation. These are also the types of streets that are the least likely to be travelled upon. Due to time constraints[20], this was not possible for the present analyses.

As predicted in the hypothesis five, most incidents occurred in areas with Catholic majorities. The number of Catholics in an area was positively correlated with the number of incidents. This provides further support for the notion that terrorists are rational actors, assessing risks and committing acts within their awareness space. The number of Protestants was negatively correlated with number of incidents. This contrasts with Berrebi and Lakdawalla's findings that the presence of a targeted group increased the risk of an attack.

As the dataset used was reliant on open source information some incidents that received very little media attention may have been unintentionally omitted. As hoax devices are a non-lethal tactic it is likely that they are under-reported. Further, as no closed source information was included there could have been many thwarted incidents that could have added further depth to these analyses. Inevitably, with all analyses of this kind, there could be errors in the reporting of the exact location where each incident occurred which may affect the outcome.

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[20] An accurate and appropriate shapefile (with street segments of equal or similar length) of the Belfast street network for use in a graph theory analysis could not be located, and as such would need to be created manually, taking a great deal amount of time).

As touched upon in the theory section, different groups have different strategies and capabilities, so it cannot be said that these results can be effectively generalised to all terrorist groups. However, this chapter again provides further support for the notion that terrorist actors behave similarly to urban criminals, as the findings suggest that they are acting rationally and carefully selecting targets.

Although this analysis has identified hotspots of terrorist activity, potential correlates of these hotspots are yet to be determined. The environmental backcloth needs to be studied to determine if there are features of the environment that may be correlated with increased risk. Studies of urban crime may focus on features such as crime attractors and generators, but there may be something else guiding terrorist activity, i.e. features related to ideology.

4.6   Conclusion

The findings of this chapter demonstrate that, like urban crimes, attacks by VDRs in Belfast were spatially and temporally clustered during the period studied. The results of these analyses may have important practical implications for policing in Northern Ireland. The hotspots identified in the analyses provide an indicator for areas which may be at an increased risk of an attack, and therefore should receive priority when it comes to patrolling and other measures such as target hardening. Prevention efforts must be proactive, not reactive (Ratcliffe, 2009) and there is a growing body of research to suggest that a focus of police resources on hot spot areas can significantly disrupt and ultimately reduce crime (Braga et al., 2014). If any measures were to be implemented using the results of these analyses, a follow up study is necessary to assess their efficacy.

The analyses revealed that KDE may be an effective way of predicting further attacks. However, although hotspots of activity have been established, any potential correlates of the hotspots are yet to be identified. Using a KDE approach in prevention efforts for terrorist attacks will not be possible in cities or towns that have experienced very few attacks. Therefore, any insights into the causes of

these hotspots will be beneficial and have the potential to be applicable across different contexts. Taking the results of this chapter, the next chapter builds on these analyses by using risk terrain modelling to determine the underlying factors causing VDR bombings and bomb hoaxes to cluster within the city.

Chapter 5   Risk Terrain Modelling of VDR incidents: a comparison of bombings and bomb hoaxes in Belfast.

5.1 Introduction

The previous chapter concluded that VDR activity in Belfast was spatially clustered during the period studied. However, the spatial analyses were unable to identify potential underlying correlates of these hotspots – just the fact they exist. This is also common in other analyses demonstrating spatial and temporal variation in risk of terrorist attacks (Berrebi and Lakdawalla, 2007; Townsley et al., 2008; Johnson and Braithwaite, 2009; Siebeneck et al., 2009; Medina et al., 2011; Behlendorf et al., 2012; Mohler, 2013; Tench et al, 2016). Fortunately, risk terrain modelling (hereafter, RTM) was developed in the study of urban crime to quantitatively assess the spatial influence of features of the urban landscape and identify areas where criminal activity is likely to emerge or persist. RTM has been applied to many different urban crimes including burglaries (Gale and Hollernan, 2013; Moreto et al., 2013), robberies (Kennedy and Gaziarifoglu, 2011; Dugato, 2013), shootings (Caplan et al, 2011; Drawve et al., 2016a), aggravated assaults (Kennedy et al., 2015; Anyinam, 2015; Kocher and Leitner, 2015), and assaults on police (Drawve and Barnum, 2018).

Because RTM includes contextual information relevant to the social and physical environment, it should be an appropriate approach to use in assessing terrorism risk. Whilst retrospective hot spot mapping attempts to predict the likelihood of future attack locations based solely on where attacks have previously occurred (Johnson et al., 2007), RTM can be used to estimate future risks of all areas according to the presence of correlated risk factors. Indeed, RTM can outperform retrospective mapping. The inclusion of environmental risk values has produced better violent crime prediction models than those produced solely with hot spots (Kennedy et al., 2011; Caplan et al., 2013a). In both Yerxa (2013) and Dugato (2013), RTM outperformed kernel density estimation (KDE). In Drawve et al.

(2016a) RTM was more precise than the nearest neighbour hierarchical (Nnh) method. Research consistently demonstrates that RTM can be an important crime prevention tool (Kennedy, 2011). However, its application to terrorist attacks has been extremely limited, with only two published studies available (according to the author's knowledge) (Onat, 2016; Onat and Gul, 2018).

This chapter examines the influences of social and physical context on target selection. The aim is to identify risk factors related to VDR activity in Belfast and to assess the predictive accuracy of this type of model. As well as being the first application of RTM to terrorism in a Western context, it is the first to compare two types of terrorist incident using this method.

5.2 Literature Review

This section begins with a discussion of the current literature regarding the use of RTM and crime. Next, to develop the RTMs used in this study, potential risk factors for VDR attacks must be determined. As such, existing target selection studies and literature relevant to the Northern Irish context is then reviewed.

5.2.1 Risk terrain modelling

Building on the foundations of environmental criminology, Caplan and Kennedy (2010) developed RTM to assess the risk of an incident occurring by analysing the level of opportunity a location may offer to an offender seeking a target. Each location has an associated value to an offender, which is determined by the opportunity for crime that it offers. RTM can be used to identify the locations that have the greatest estimated opportunity and therefore pose the highest level of risk. RTM identifies features that are potentially correlated with the presence or absence of future event(s) in a particular location. The presence of relevant features that are deemed to have a spatial influence on increasing the likelihood of crime determine the level of risk. In combination, these correlates of criminal events can identify areas within a city at the highest risk of future incidents.

As previously stated, RTM has been applied to a wide number of crime types and the spatial features examined vary from study to study. For example, Gale and Hollernan (2013) applied RTM to residential burglaries. They found significant associations between burglaries and concentrations of bus stops, which can offer an offender easy access and escape when committing their crimes. Calls to the police regarding suspicious vehicles and persons were also significant correlates for residential burglary. The areas with the highest concentrations of these three factors had the highest concentration of offences. Moreto et al. (2013) found residential burglaries were more likely to occur in places spatially influenced by factors such as the presence of pawn shops, at-risk housing and drug markets.

Kennedy and Gaziarifoglu's (2011) analyses of street robbery found five associated risk factors: bus stops, retail venues, banks, drug arrests and prostitution arrests. Once these factors had been combined and reclassified according to risk levels, they concluded that a robbery was almost 2.3 times more likely to occur with every unit increase in the risk value of a cell. Dugato (2013) identified transport stations, public housing, prostitution offences, banks, licensed premises and post offices as risk factors for robberies. Daley et al. (2016) applied RTM to identify areas at high risk of instances of child maltreatment, including neglect, physical abuse and sexual abuse. In the year after the study, half of all instances occurred in the top 10% of the areas deemed as having the highest risk, with 98% of cases occurring in areas that were identified by the model as being at elevated risk.

RTM has also been successfully applied to violent crimes, such as shootings (Caplan et al., 2011). Kennedy et al. (2015) found known problem buildings, foreclosures, and gang hotspots to be significantly correlated with aggravated assaults in Chicago. Interestingly, variables typically associated with assaults in other cities, such as bars and liquor stores, were less likely to be associated with this type of crime within the Chicago context. Drawve et al. (2016a) tested the predictive accuracy of RTM for shootings (Drawve et al., 2016a). Six of the seven social and physical environmental measures they tested in the RTM significantly predicted future gun crime locations: on-site consumption and off-site

consumption alcohol establishments; fast food establishments; drug incidents; percentage of black residents and percentage of male residents. Drawve and Barnum (2018) applied RTM to aggravated assault and found bus stops and liquor stores to be significant risk factors.

Although the application of RTM to terrorism has been limited, it has been used to identify risk factors related to armed conflict (Gaziarifoglu et al., 2012) which include variables commonly used to study terrorism, such as population density, political instability and ethnic or religious divisions in society (i.e Fearon and Laitin, 2003; Collier and Hoeffler, 2004; Goldstone, 2010). However, almost all risk indicators identified so far are based on studies of armed conflict in African countries and therefore may yield different results to those in Europe (Buhaug and Rød, 2006). Prior studies are also largely focused on social factors (Fearon and Laitin, 2003; Collier and Hoeffler, 2004; Goldstone, 2010), which tend to be consistent across large geographical areas, and as such provide little utility to prevention efforts at micro places

To the author's knowledge, at present there have only been two applications of RTM to terrorist attacks at the micro level. Onat (2016) identified areas that were at risk of attack from terrorist groups in Istanbul. He found the riskiest factor in the urban environment to be the presence of bakeries. Although this type of building has no symbolic value, bakeries have a social meaning in Turkish culture and are visited frequently by most residents. Thus, bakeries have a role in an individual's daily routine. Because they attract large numbers of people daily, they can be considered a generator for many available targets. This again highlights the importance of considering an individual's every day behaviour, and their awareness space (Brantingham and Brantingham, 1981), in the selection of targets. Other significant correlates included religious facilities, bars and clubs, and grocery stores. Whereas these latter significant correlates may be generalisable to other conflicts, the presence of bakeries may be culturally-specific to certain contexts. Thus, RTM's application to terrorism warrants further testing in non-similar cities.

Building from the prior RTM study of terrorism in Istanbul, Onat and Gul (2018) identified differences in terrorist targeting according to two ideologies: separatist and leftist groups. Grocery stores, bakeries, bars/clubs, and educational facilities were identified as risk factors for both types. They also found differences in risk factors for attacks by each group. Religious facilities and office blocks were significant correlates of separatist attacks but not for leftist attacks. Government buildings were found to be a significant risk factor for leftist attacks only. This paper also built on Onat (2016) by testing the predictive accuracy of the RTM. In the 20 month period following their RTM, almost half of the attacks occurred in the top 10% highest risk cells, and nearly 80% in the top 20% highest risk cells. The model was based on the preceding 36-month period.

5.2.2 Spatial risk factors of VDR attacks

To test the utility of RTM for terrorism, as well as to generate the relevant hypotheses and risk factors, it was necessary to first select a geographical area that had experienced several incidents. Belfast was selected as the city has been central to the Northern Ireland conflict and experienced the most VDR activity to date. Next, to develop the RTM, potential risk factors for VDR attacks had to be determined through a review of existing target selection literature to identify potential correlates. These were then operationalised to geographic units over a continuous surface, and incorporated into the model. The following features were considered: crime generators and attractors, symbolic buildings related to ideology, the social context and other related VDR activity.

Crime generators are places that attract large numbers of people for reasons unrelated to criminal motivation, but offer increased opportunities for crime due to the high footfall (Clarke and Eck, 2003). For terrorist attacks, crime generators are likely to attract offenders due to the large amount of people in one space, therefore increasing the likelihood of a high number of casualties and witnesses, and increased likelihood of disruption. These areas also offer easy means of escape, as the attacker can move discreetly throughout the crowd. As suggested above, the existing RTM literature consistently suggests two types of such crime

generators: commercial establishments (pubs/bars, restaurants/cafes, shops) and transport hubs. Additionally, for the Northern Ireland context, it might be worth considering the presence of sports clubs. Such locations, such as football clubs, attract large numbers of people and play an important part in Northern Irish culture (Kurland et al., 2014a, 2014b). Football is religiously divided in Northern Ireland (Bairner and Shirlow, 1998; Cronin, 2000), and violent conflict between clubs is well known and documented (Bairner, 1999).

Ideology impacts terrorist targeting because it "sets out the moral framework within which they operate" (Drake, 1998, p.53). There should therefore be some consideration of VDR ideology and this further highlights the need for conflict-specific risk terrain modelling. Since VDRs reject UK government rule in Northern Ireland, government buildings are likely to act as crime attractors due to the quantity of government workers present in the buildings and in the surrounding areas. When considering urban crimes, premises such a police stations can be considered as crime detractors. However, VDR groups consider the police an illegitimate force in Northern Ireland. It is likely therefore that premises such as police stations will act as crime attractors, due to their symbolic nature. This also further highlights the need for crime-specific risk terrain modelling. The Orange Order (The Loyal Orange Institution), whose members are overwhelmingly Protestant, are in favour of Northern Ireland's union with the UK. There has been a lot of conflict surrounding Orange Order marches, where individuals march carrying flags depicting scenes from Protestant and Orange Order history (Kaufmann, 2007). There is therefore the possibility that Orange Order halls and lodges could act as attractors.

Gimenez-Santana et al.'s (2017) RTM of crime in the highly segregated city of Bogota, demonstrates the utility of examining the social context of a city. Low strata neighbourhoods were significantly correlated with personal injury and homicide. High strata neighbourhoods were significantly correlated with theft. In Northern Ireland, churches are a good measure of the religious segregation that is a defining characteristic of the social context. Belfast, in particular, is highly segregated and it is likely that the religiosity of the area would influence target

selection. It may be that areas within the city with a Catholic majority are more likely to be attacked as it is likely that they are more familiar with certain areas and would also be less likely to be detected as a member of the 'opposition'. As demonstrated in the previous chapters of this thesis, areas within an individual's awareness space are more likely to be targeted. Catholic churches may therefore serve as 'risky places' for attacks. On the other hand, it could be that a Catholic majority could deter offenders choosing these areas as to not risk attacking someone they know, and areas with a Protestant majority may offer a higher number of targets. Therefore, the effects of both will be examined.

RTM research also demonstrates the importance of considering other (perhaps related) crimes in the modelling. For example, Kennedy et al (2011) successfully predicted the location of shootings by using drug arrests as a risk factor because the underlying factors that drive these crimes are similar (e.g. high levels of gang related activity in areas that are socially disorganised). Gale and Hollernan (2013) found a statistically significant association between burglary and calls for suspicious persons and vehicles. Dugato et al's (2017) RTM of organised crime violence in Italy from 2004-2011 found that other crime activities of the group such as drug-dealing were significant correlates of mafia homicides (Dugato et al., 2017). 85% of homicides for 2012 occurred in high risk areas. Such predictors out-performed social disorganisation variables, such as poor socio-economic conditions, percentage of unemployed residents and residential instability, which were non-significant. Escudero and Ramirez (2018) found that illicit drug markets were significantly correlated with motorcycle thefts. Anyinam (2015) found the most important predictor for violent crimes to be public calls regarding drug offences. As discussed in chapter 2, localised violent vigilantism, such as punishment attacks (Morrison and Horgan, 2016) are a defining feature of the current VDR threat. These acts of violence committed by terrorists are designed to gain support and power within their community. Therefore, other known VDR activity, such as punishment attacks, protests and riots, and arms finds should be included.

5.2.3 Differences in attack type

Different types of crime exhibit different spatial patterns (Andresen and Linning, 2012). Barnum et al's (2017) examination of drug dealing locations in Chicago found grocery stores and foreclosures to be risk factors across all types of drugs studied (cannabis, heroin, crack and cocaine). However, the degree of spatial influence of these common risk factors varied. There were also multiple other risk factors that varied for each drug, for example parks and homeless shelters were correlates of heroin dealing only. This highlights the importance of disaggregating data.

Any analysis of terrorist activity should consider differences between attack types, as they serve different purposes. For bomb hoaxes, the goal is not to cause casualties, but to occupy the security services' time and portray them as ineffective. Also, the associated risks with carrying out a successful bombing are much higher than a bomb hoax. Building a viable device requires a higher level of capability and resources. A bomb may need to be activated by someone in the vicinity shortly before, whereas a bomb hoax can be left for a long period of time. Therefore, it is likely that there is more consideration about risk of detection and ease of escape in the commission of an attack involving a viable device, so the locations of these types of incidents should differ.

5.3 Data and Analytical Strategy

5.3.1 Incident Data

The dataset of VDR incidents used for the analyses included the bombings and bomb hoaxes from the final working dataset used in Chapter 4. To maximise the utility for potential use by practitioners only attacks that took place during the most recent wave - January 2007 to December 2016 (the Contemporary wave as

defined by Morrison and Horgan, 2016) - were used for the analyses[21]. All bombings and bomb hoaxes within this period where an accurate geographical location was known[22] were used for the subsequent analyses[23]. Incidents from January 2007 to December 2013 were used to develop each RTM, and incidents from January 2014 to December 2016 were used to test the accuracy of each model. Each dataset was geocoded and converted into a point file, to be used as the event data for the relevant model.

5.3.2   Risk factors

To operationalise the risk factors, data was obtained from several sources. The geographical (polygon) data for Belfast was obtained from the Northern Ireland Statistics and Research Agency (NISRA). Most locations of the physical infrastructure to create the feature sets were obtained from Open Data NI. This included the following: pubs, bars, restaurants, cafes, sports clubs, Catholic and Protestant churches, railway and bus stations, and government buildings. Addresses for PSNI stations were obtained from an existing dataset created by John Morrison. The locations of Orange Order Lodges were received from Professor Eric Kaufmann (Birkbeck College, University of London). The data concerning protests/riots, arms finds and punishment attacks was drawn from the original VDR project dataset mentioned in the previous chapter. Each feature set was geocoded and converted into a point shapefile and then a raster layer using ArcGIS. These were used to represent the presence or absence of each risk factor in each grid square.

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[21] As discussed in chapter 4, Sinn Fein's decision to support the PSNI marked the beginning of this wave, which saw a substantial increase in VDR incidents compared to the preceding years.

[22] As mentioned in chapter 4, it was necessary to remove 2 bombings and 1 hoax due to missing geographical information.

[23] All bombings and hoaxes included as outcome events were distinct from any other VDR activity included in the risk factors. For example, none of the bombing events occurred during any of the riots. This was to prevent overlap of incidents which could invalidate the results.

5.3.3 RTMDx

The RTMDx Diagnostics Utility (Caplan and Kennedy, 2013; Caplan et al., 2013b) software automates the statistical procedures involved in RTM and was used to identify the significant risk layers. This tool evaluates the relative influence and importance of risk factors using a bidirectional stepwise regression process. The variables are examined and the most problematic risk factors are selected, along with their most appropriate spatial influence distance, to build the overall best model.

The software requires several parameters to be set prior to analysis. The relevant file of event data (aggregated to raster cells) was selected as the outcome event for each model. The polygon shapefile of Belfast was used to define the boundary to be tested. RTMDx allows for two types of model: aggravating (to identify factors that increase risk) and protective (to identify factors that decrease risk). An aggravating model was used for all analyses conducted in this chapter, to determine which factors increased the risk of VDR incidents.

The parameter 'operationalisation' was used to select how the spatial influence of each variable was to be assessed, based on proximity or density. Spatial influence for *proximity* is operationalised as the presence of a physical feature within the defined distance from the event. Spatial influence for *density* is operationalised as a high concentration of a physical feature within the defined distance from the event. To determine which of these two functions was appropriate, it was necessary to compute a nearest neighbour index (Nni) for each risk factor using the CrimeStatIV software to determine whether they were clustered. As discussed in chapter 4, a nearest neighbour index (Nni) of less than 1 is indicative of clustering, values of more than 1 are indicative of dispersion. Risk factors that were significantly clustered were operationalised by 'density', and those that weren't were operationalised by 'proximity' (see table 5.1).

Table 5.1. Nearest neighbour indexes and operationalisations of risk factors to be used in the model

Risk factor	Nni	z-score	p-value	Operationalisation
Catholic churches	1.14	1.17	0.24	Proximity
Government buildings	1.03	0.24	0.81	Proximity
Orange Order Lodges	0.17	-21.84	<0.001	Density
Police stations	1.26	2.05	0.04	Proximity
Protestant churches	1.09	1.22	0.22	Proximity
Pubs/bars	0.73	-5.78	<0.001	Density
Restaurants/cafes	0.56	-15.04	<0.001	Density
Shops	0.53	-18.58	<0.001	Density
Sports clubs	0.82	-2.56	0.01	Density
Transport hubs	1.25	1.41	0.1	Proximity
Arms Finds	2.07	4.08	<0.001	Proximity
Protests/Riots	1.5	3.3	<0.001	Proximity
Punishment Attacks	0.58	-6.18	<0.001	Density

It was also necessary to define the grid cell size for the outputs. Caplan and Kennedy suggest that using the average street length (in this case 100m), with a cell raster size of half a street length (50m) is appropriate to create the cells. To maximise the potential utility of the model, the risk factors were operationalised to a maximum spatial influence of 400m (four streets). Taylor and Harrell (1996) propose that places prone to crime consist of a few streets, and this measure is a realistic area to use for the guidance of future policing measures. Each file was converted into a raster layer via the Density and Proximity Tools in ArcMap's Spatial Analyst extension. Each raster map contained equally sized 50mx50m cells to reflect half of the average street length in Belfast, as measured within ArcMap. Each cell received a count of points falling within its boundaries.

The first model used bombings as the outcome event, and the second model used bomb hoaxes. For each model, the 13 risk factors (pubs/bars; restaurants/cafes; shops; sports clubs; transport hubs; police stations; government buildings; Orange Order lodges; Catholic churches; Protestant churches; punishment attacks; protests/riots; arms finds) generated 52 variables (testing the spatial influence of each risk factor as a function for either proximity or density at 100m, 200m, 300m and 400m) that were tested for significance.

The testing process began by building an elastic net penalised regression model assuming a Poisson distribution of events. The process then selected variables that may be potentially useful through cross validation, which were then utilised in a bidirectional step-wise regression process (starting with a null model), to build the optimal model by optimising the Bayesian Information Criteria (BIC). This score is a balance of complexity of the model and fit of the data.

The models also include two intercept terms that represent the background rate of events and overdispersion of the event counts. Exponentiated coefficient values were used to produce the relative risk values, which can be interpreted as the weights of the risk factor (Caplan et al., 2013b). These can be used to understand the riskiness of each factor relative to one another.

5.4 Results

5.4.1 Bombings

The RTMDx Utility determined that the best risk terrain model for bombings was a Negative Binomial type II model with 3 risk factors and a BIC score of 1174.1. The selected risk terrain model was assigned relative risk scores to cells ranging from 1 for the lowest risk cell to 460.1 for the highest risk cell. A cell with a value of 460.1 has an expected rate of bombings that is 460.1 times higher than a cell with a value of 1.

Previous protests and riots were the riskiest factor for this model,[24] with a relative risk value of 14.07 and a spatial influence of 100m. In other words, areas within 100 metres of a previous protest or riot posed over 14 times greater risk of experiencing a bombing than other areas not within this realm of spatial influence. The second riskiest factor was areas dense with punishment attacks with a relative risk value of 6.56 and a spatial influence of 300m. Areas dense with pubs and bars had a relative risk value of 4.98, with a spatial influence of 200m. The spatial operationalisation of 'density' suggests that risk is more pronounced at places where these risk factors are densely clustered.

Table 5.2. Results of the bombings RTM

Name	Operationalisation	Spatial Influence (m)	Coefficient	Relative Risk Value
Protests/Riots	Proximity	100	2.6443	14.0736
Punishment Attacks	Density	300	1.8809	6.5594
Pubs/bars	Density	200	1.6062	4.9838
Intercept			-6.9640	
Overdispersion			-1.5247	

A point density layer for the risk factors operationalised by density were derived using the ArcGIS 'Kernel Density' tool, and those based on proximity were created using the 'Euclidean Distance' tool. They were then combined to produce a composite risk terrain map for each of the two models (see figures 2 and 3). Using 'Map Algebra' in the 'Raster Calculator' function in the 'Spatial Analyst' extension in ArcMap the risk terrain map (figure 2) for bombings was produced using the following formula (generated by the RTMDx software):

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[24] Upon this finding, a separate RTM was conducted for protests and riots to determine whether the risk factors for these incidents overlapped with the risk factors for bombings. Different risk factors were found, meaning it is unlikely that the same environmental dynamics are driving this.

Exp(-6.9640 + 2.6443 * "Protests" + 1.8809 * "Punishment Attacks" + 1.6062 * "Pubs/Bars") / Exp(-6.9640)

For the risk terrain maps (figures 1 and 2) Belfast was modelled as a continuous surface grid of 100m x 100m cells. Each cell was reclassified into 1 of 4 risk levels, according to standard deviational breaks. Low risk was classified as a cell value between 0 and the mean cell value (1.47); medium risk was classified as a cell value between the mean and 1 standard deviation (SD) (1.48-6.28); high risk was between +1SD and +2SD (6.29-11.09); and very high risk were all cell values above +2SDs (>11.09).

Figure 5.1. Risk terrain map for bombings in Belfast 2007-2013
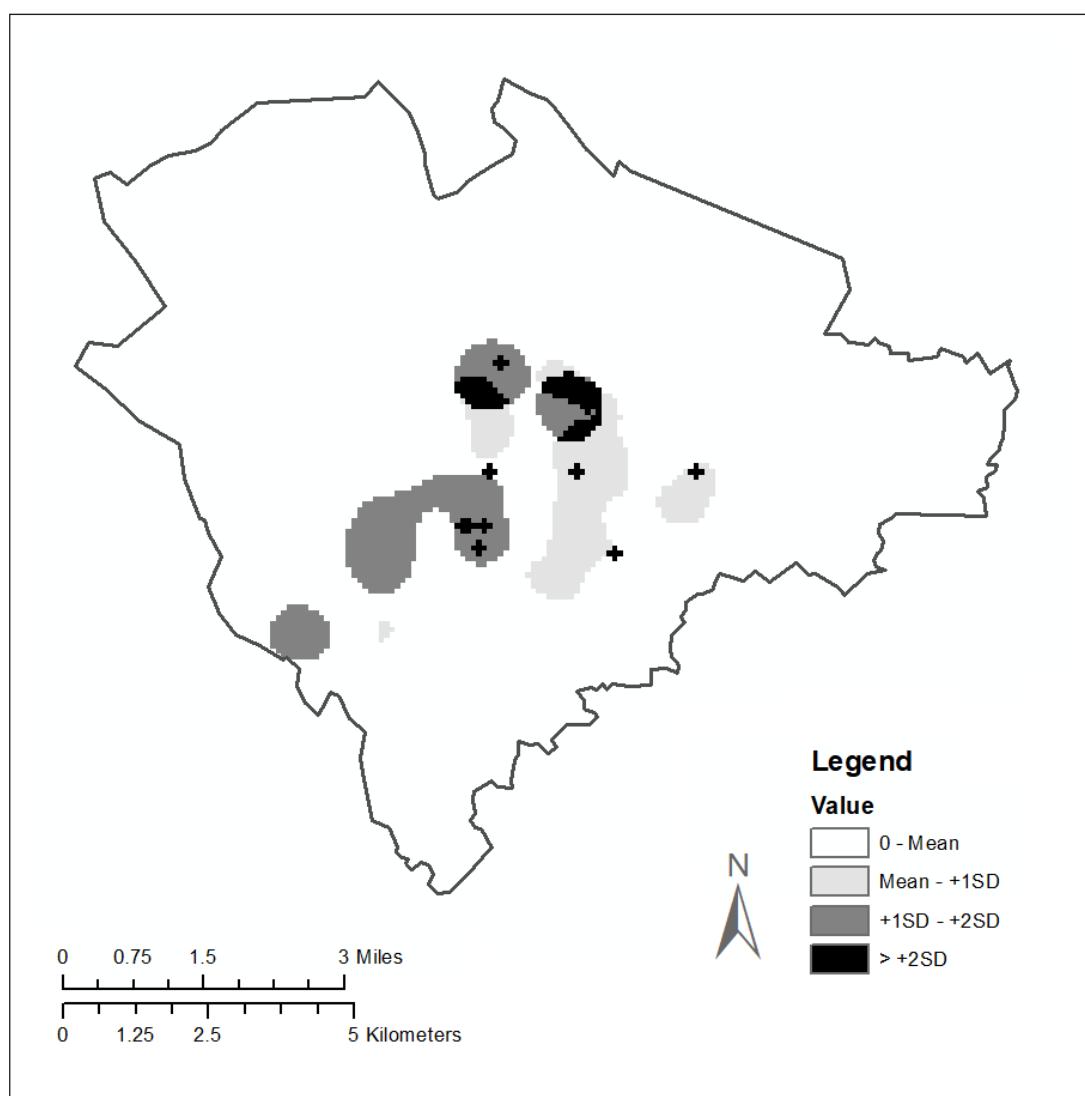
5.4.2   Bomb Hoaxes

For bomb hoaxes, the RTMDx Utility determined that the best risk terrain model was a Negative Binomial type II model with 3 risk factors and a BIC score of 1195.2. The selected risk terrain model was assigned relative risk scores to cells ranging from 1 for the lowest risk cell to 94.3 for the highest risk cell.

Punishment attacks were the riskiest factor for this model, with a relative risk value of 10.77 and a spatial influence of 100m. In other words, areas within 100 metres of a previous punishment attack posed almost 11 times greater risk of experiencing a hoax than other areas not within this realm of spatial influence. This was followed by police stations with a relative risk value of 8.76 and a spatial influence of 200m, and places dense with shops, with a relative risk value of 6.94 and spatial influence of 400m.

Table 5.3. Results of the bomb hoaxes RTM

Name	Operationalisation	Spatial Influence (m)	Coefficient	Relative Risk Value
Punishment Attacks	Density	100	2.3764	10.7661
Police Stations	Proximity	200	2.1703	8.7609
Shops	Density	400	1.9378	6.9435
Intercept			-7.1510	
Overdispersion			-2.1445	

For bomb hoaxes, the formula (generated by the RTMDx software) for the risk terrain map (figure 3) was as follows:

Exp(-7.1510 + 2.3764 * "Punishment Attacks" + 2.1703 * "Police Stations" + 1.9378 * "Shops ") / Exp(-7.1510)

Figure 5.2. Risk terrain map for bomb hoaxes in Belfast, 2007-2013
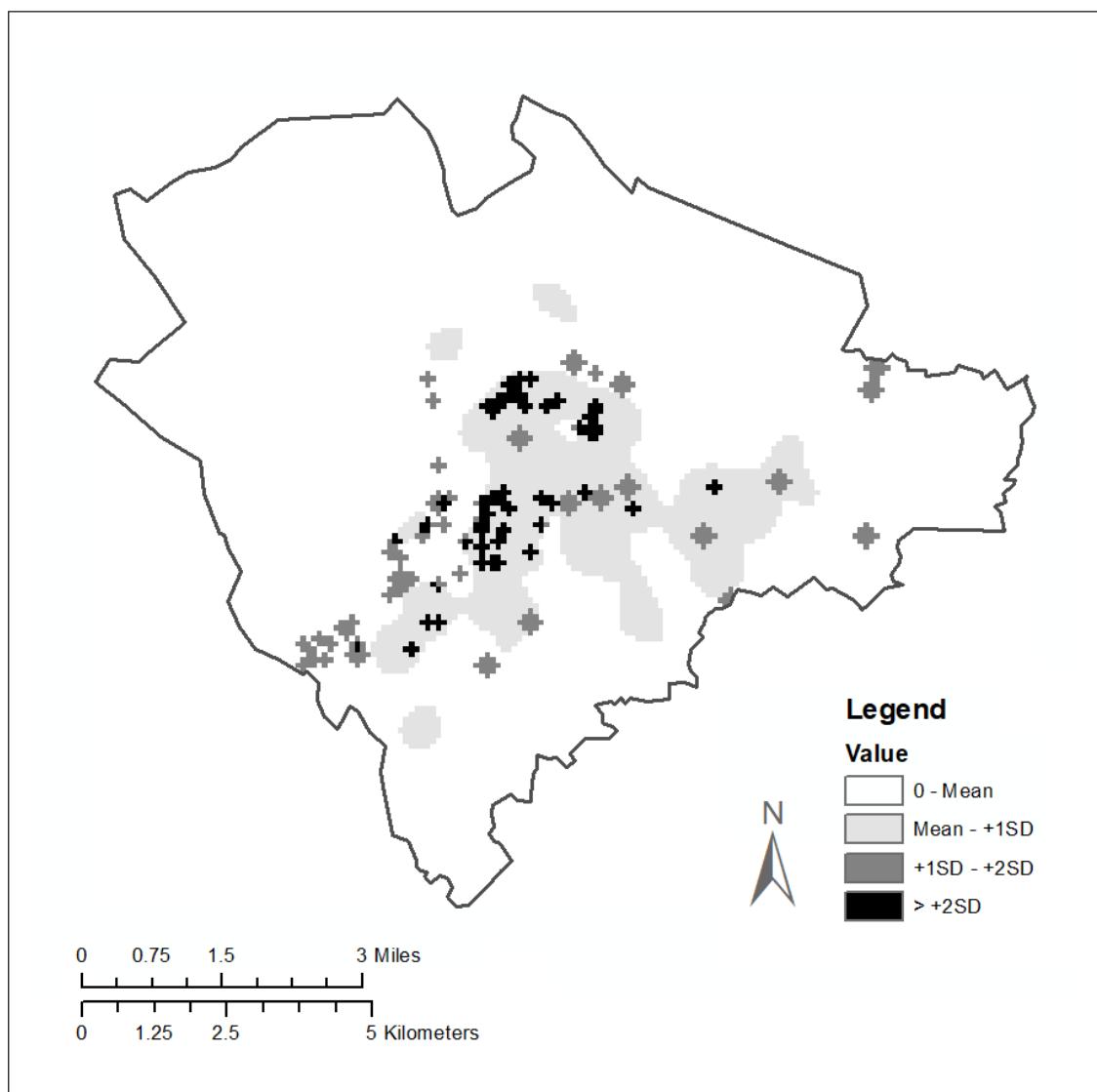
As before, each cell was reclassified into 1 of 4 risk levels. Low risk: 0 – mean (0-2.21); medium risk: mean - +1SD 2.22-10.61); high risk: +1SD - +2SD (10.62-19.01) and very high risk were all cell values above +2SDs (>19.01).

5.4.3 Predictive Accuracy

The risk terrain maps presented in figures 2 and 3 show the areas within Belfast that are most likely to attract or enable bombings and bomb hoaxes. In line with previous research it would have been preferable to run binary logistic regressions to ascertain the predictive accuracy of the models. However, due to an insufficient amount of data, this was not possible. Therefore, descriptive statistics are provided in table 5.4, using the locations of bombings and bomb hoaxes that occurred between 2014 and 2017. These results demonstrate that several post-2013 incidents occurred in places that appear to be the most vulnerable.

Table 5.4. Locations of 2014-2017 bombings and bomb hoaxes according to risk level

	Frequency	
Risk Level	**Bombings**	**Bomb Hoaxes**
1 (0 – mean)	12	0
2 (mean - +1SD)	2	4
3 (+1SD - +2SD)	7	2
4 (> +2SD)	7	2

Bombings

During the test period, 28 bombings occurred. Seven bombings occurred in the cells that were inferred as being at very high risk. Seven occurred in high risk cells. 2 bombings occurred in medium risk cells and 12 bombings occurred in areas deemed to be at low risk.

Figure 5.3. Risk terrain map with 2014-2017 bombings (n=28)
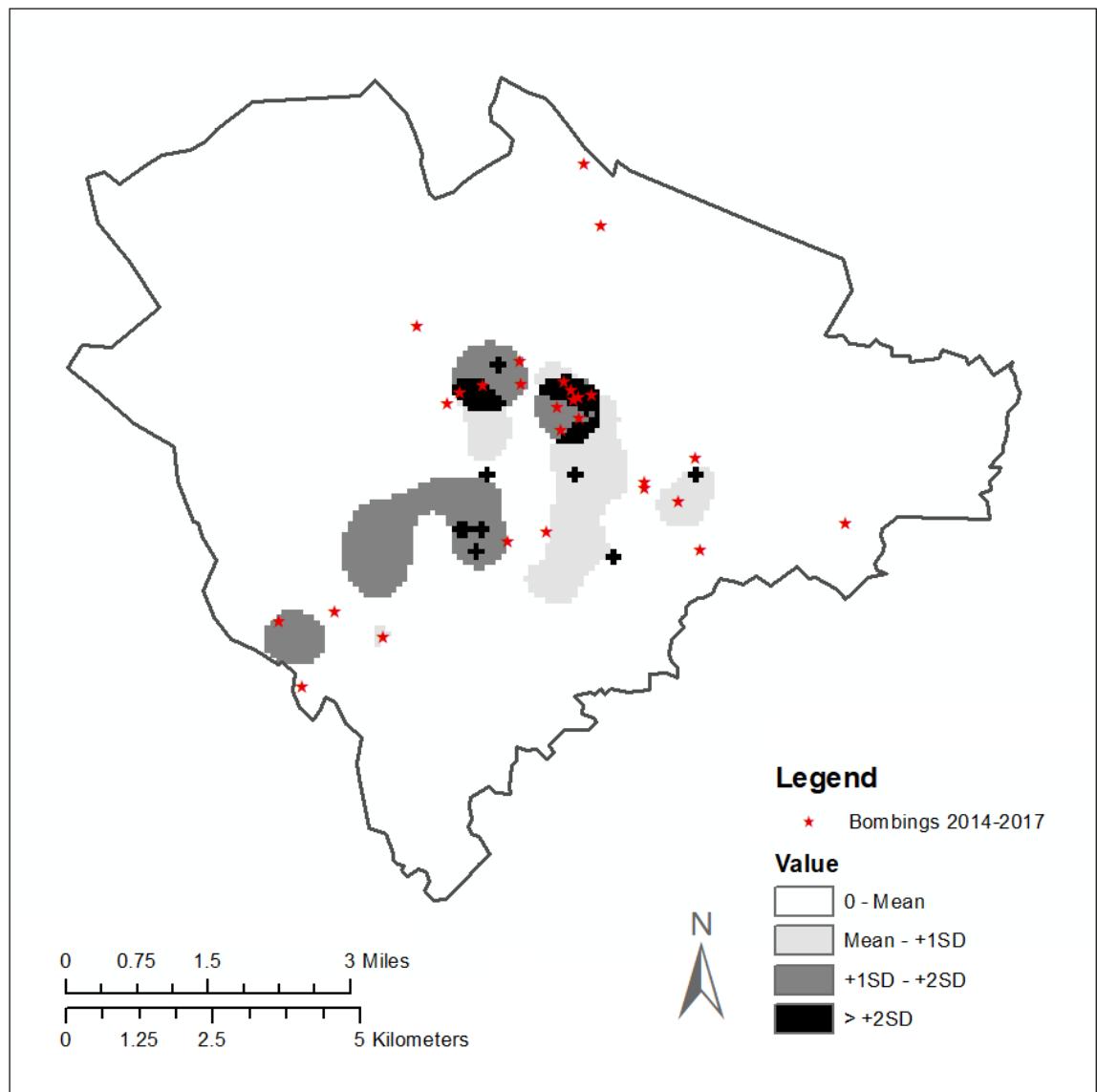
Bomb hoaxes

Eight hoaxes occurred post-2013. Four occurred in medium risk areas, two in high risk areas and two in very high risk areas. No hoaxes occurred in areas deemed to be at low risk.

Figure 5.4. Risk terrain map with 2014-2017 bomb hoaxes (n=8)
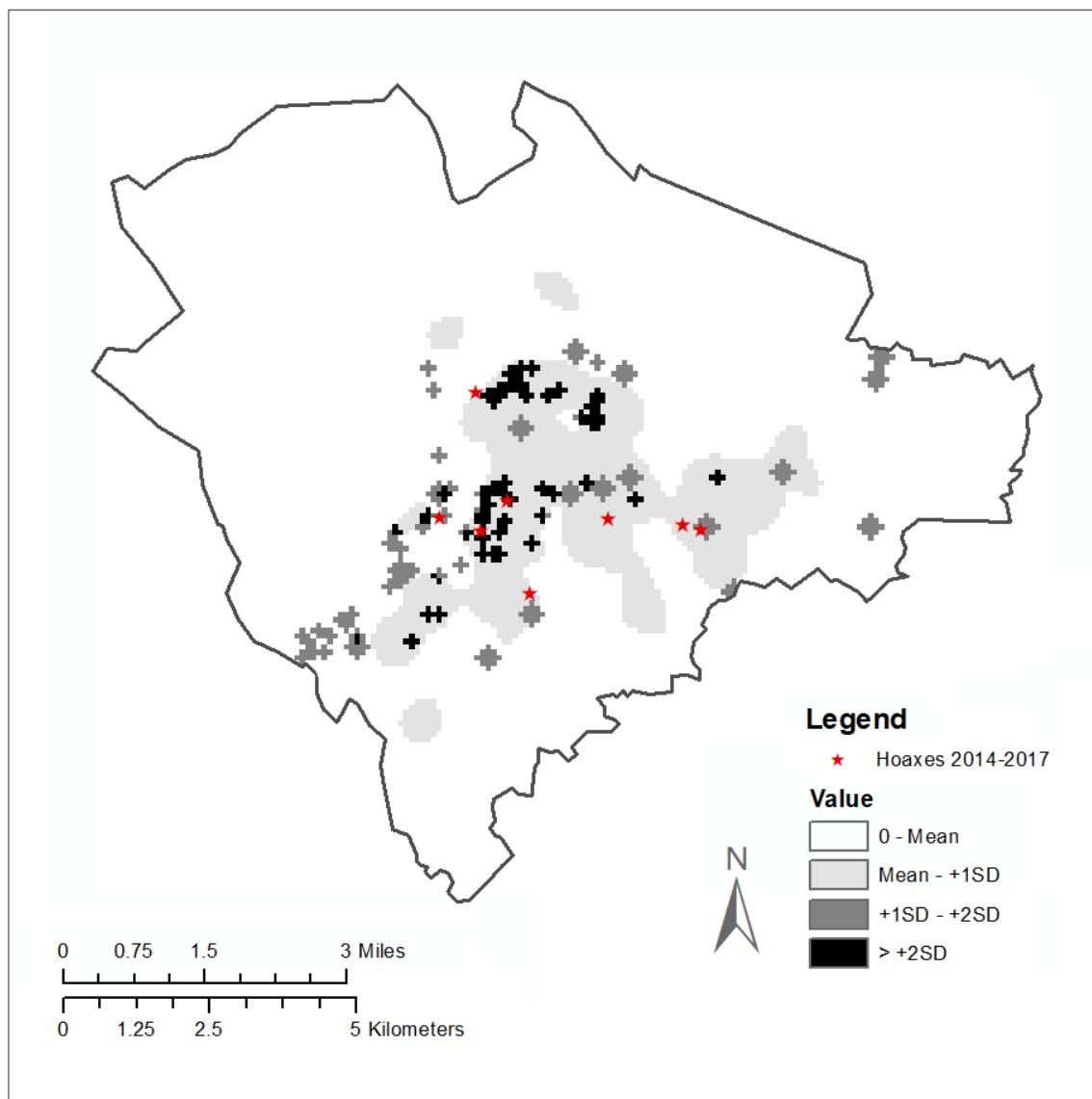
5.4.4 Further Models

The riskiest factors identified in both models were other related VDR activity (protests/riots and punishment attacks). A further model for each incident type was run with the related VDR activity variables excluded, to ascertain if the models would be accurate in identifying high risk areas without this information.

The same procedure was followed as before, but with the VDR related activity risk factors (arms finds; protests/riots; punishment attacks) excluded.

For bombings (see table 5.5), the best RTM was a negative binomial type II model with 2 risk factors and a BIC score of 1210.1. Pubs/bars were the riskiest factor, followed by shops.

Table 5.5. Results of the bombings RTM with VDR activity excluded

Name	Operationalisation	Spatial Influence (m)	Coefficient	Relative Risk Value
Pubs/bars	Density	200	1.4967	4.4669
Shops	Density	100	1.2377	3.4477
Intercept			-6.8016	
Overdispersion			-1.4412	

For hoaxes, the best RTM was a negative binomial type II model with 3 risk factors and a BIC score of 1162.9. Shops were the riskiest factor, followed by police stations and Catholic churches.

Table 5.6. Results of the hoaxes RTM with VDR activity excluded

Name	Operationalisation	Spatial Influence (m)	Coefficient	Relative Risk Value
Shops	Density	400	1.4646	4.3258
Police Stations	Proximity	300	1.2377	3.4851
Catholic Churches	Proximity	400	1.1809	3.2573
Intercept			-7.1408	
Overdispersion			-2.3350	

The risk terrain maps and the locations of the post-2013 events are presented in figures 5.5 and 5.6. These maps and the accompanying comparison table (see table 5.7) demonstrate that the exclusion of other VDR related activity may weaken the accuracy of identifying high risk areas.

For bombings, sixteen occurred in low risk areas, ten in medium risk, and two in very high risk areas. For hoaxes, four occurred in low risk areas, one in medium risk areas, and three in high risk areas. No hoaxes occurred in very high risk areas. More post-2013 events occurred in areas deemed to be at low risk for the second model than the first. On this basis it can be concluded that the inclusion of other activity related to the group being studied is useful and beneficial.

Table 5.7. Comparison of accuracy of models in predicting locations of incidents

Risk Level	Frequency			
	Bombings Model 1	Bombings Model 2	Hoaxes Model 1	Hoaxes Model 2
1 (0 – mean)	12	16	0	4
2 (mean - +1SD)	2	10	4	1
3 (+1SD - +2SD)	7	0	2	3
4 (> +2SD)	7	2	2	0

Figure 5.5. Risk terrain map with 2014-2017 bombings (VDR related activity excluded) (n=28)
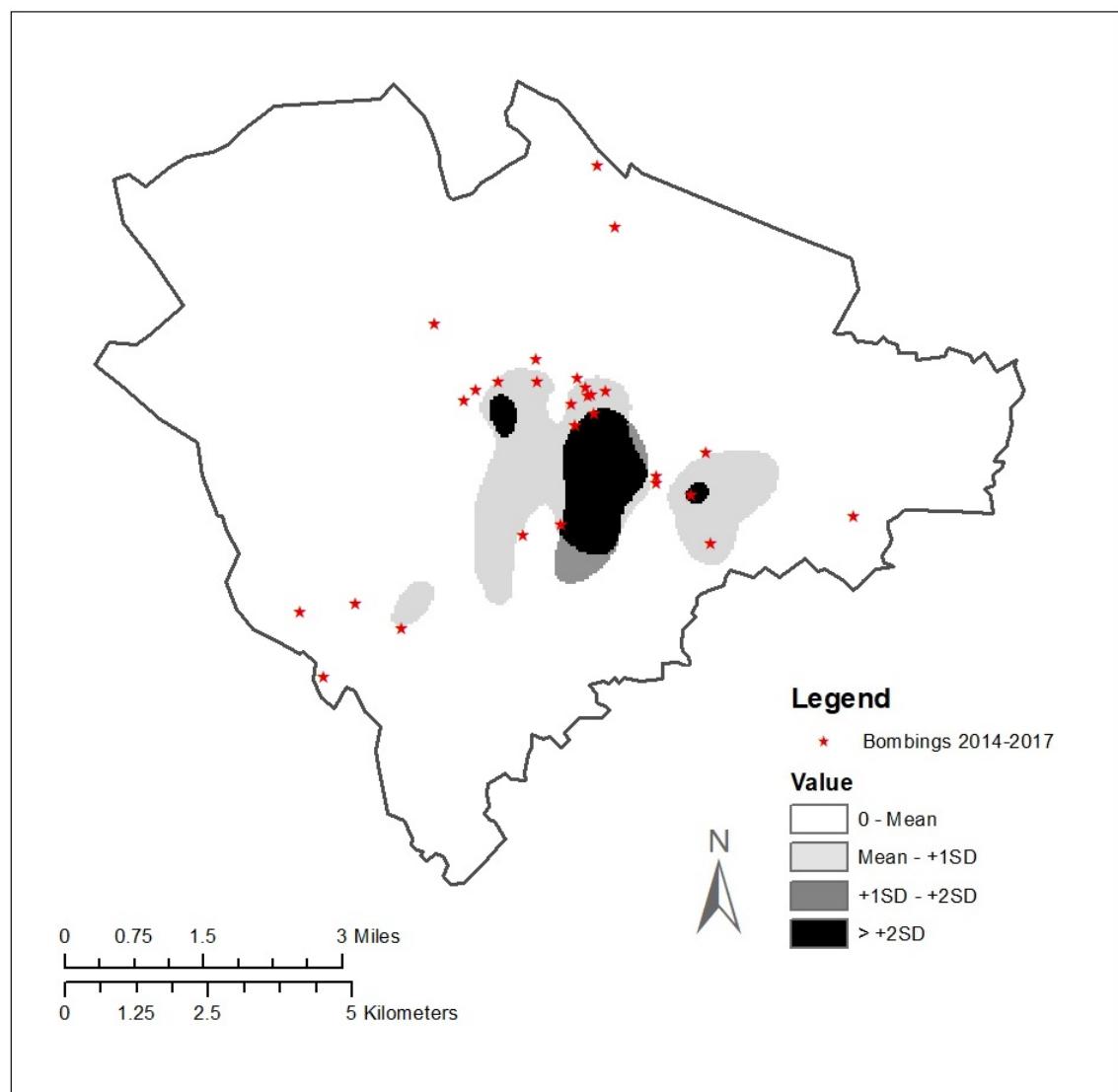
Figure 5.6. Risk terrain map with 2014-2017 bomb hoaxes (VDR related activity excluded) (n=8)
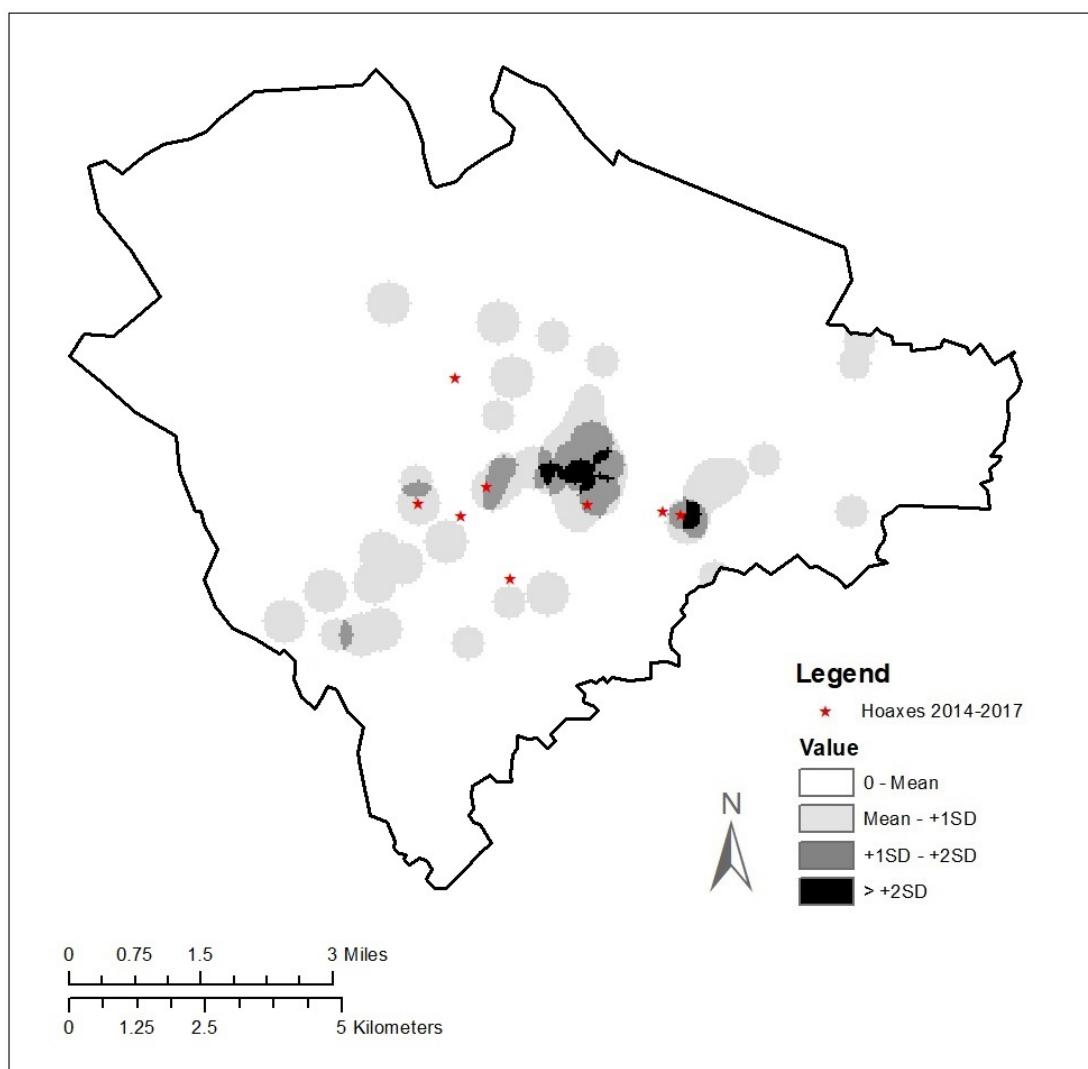
5.5   Discussion

This chapter identified areas in the city of Belfast that could be at risk for future incidents of VDR incidents, based on the spatial influence of features identified through a review of previous literature. A combination of factors, determined through the RTMs, contributed to the associated risk levels. Different risk factors were identified for the two incident types. The results indicated that previous experience of protests/riots and punishment attacks, and the presence of pubs/bars were associated with bombings. Previous experience of punishment attacks and the presence of police stations and shops were associated with bomb hoaxes.

To be consistent with previous research such as Caplan et al. (2010), a binary logistic regression was originally planned to determine whether bombings and bomb hoaxes in a second defined period occurred in cells which were deemed to be 'high risk'. However, the total dataset was deemed too small to split reliably and in a meaningful manner. The descriptive statistics that were implemented as an alternative are promising and indicate that it may be useful to incorporate this method in guiding counter-terrorism measures. However, some caution should be advised due to the small amount of data used to test this. Half of bombings and bomb hoaxes in the post-RTM study period occurred in high or very high risk cells, and it can be suggested that these areas should be hardened where possible. Seeing as only a small proportion of the city was deemed to be at the high or very high levels of risk, this is impressive. However, a large proportion (43%) of bombings did occur in low risk cells. Although several did occur very close to areas deemed to be at risk, the predictive accuracy of this method is therefore difficult to determine. If enough data for further years post-RTM could be obtained, a logistic regression could be used to see if the odds of a bombing or bomb hoax occurring increases as the spatial risk value of the cells increases.

The riskiest factor for bombings was protests/riots. This was followed by punishment attacks which were also the riskiest factor for bomb hoaxes. It is likely that these areas would have been known to the individuals involved in the attacks,

and the increased familiarity with these areas increases the recognition of opportunities, as well as ease of escape. This concurs with the results of Onat's (2016) RTM study of PKK attacks in Turkey, where bakeries were found to be a significant correlate due to their role in individuals' daily routines. This highlights the importance of considering other known activity of the group being studied. The further models were used to demonstrate the utility of including other related VDR activity. These models, where the VDR related variables were excluded, were weaker in identifying high risk areas for incidents in the 3 year post-study period.

The RTM was more accurate than the KDEs in chapter 4 in identifying high risk locations for bombings. During the test period of January 2014 to December 2016, 14 bombings occurred in high or very high risk cells for the RTM, compared with just 3 in high or very high density for the KDE. Retrospective analyses such as KDE cannot consider the influence of underlying social and physical factors, such as the influence of related VDR activity. The variables related to other VDR events were identified as strong influences on the locations of bombings. This finding is consistent with Dugato, Calderoni and Berlusconi (2017), who found the highest correlates of mafia homicides in Naples to be other Camorra related activity.

For hoaxes, 4 occurred in high or very high risk cells for the RTM compared with 5 in high or very high density cells for the KDE. 2 occurred in low or very low density areas, however none occurred in low risk areas identified by the RTM. As there was a small amount of data available to test the hoaxes, it is difficult to determine the predictive accuracy of RTM compared to KDE for this type of incident.

It was proposed that there may be an increased risk in areas surrounding premises relevant to the group's ideology. Police stations were identified as risky places for bomb hoaxes, however this risk factor was not significantly correlated with bombings. This difference could be explained by the perceived level of security at these premises and therefore increased likelihood of

detection/reduced likelihood of success. As Morrison and Horgan (2016) effectively highlight in their study of VDR target selection, the targeting of police services naturally comes with a higher risk of arrest, due to the presence of police officers surrounding the point of attack. This result suggests that there is some assessment of risk by the offenders, and that they are selecting targets rationally. This is consistent with the findings of Gill et al. (2018), who concluded that fear of detection plays a strong role in the decision-making encompassing a terrorist event by those groups not intending the offender's death at the scene of the attack. It can be proposed that there may be differences between targets relevant to ideology and realistic targets with increased chance of success.

Places dense with pubs and bars were significantly correlated with bombings, and those dense with shops were significantly correlated with bomb hoaxes. Urban areas that have a high human density with plenty of foot flow and low levels of security are vulnerable to attacks. They allow the attacker to operate discretely, increase the chances of escaping undetected, and offer a predictable amount of human density. As well as these factors, the high concentration of individuals also makes these areas an attractive target due to the number of potential casualties and fatalities. These findings are consistent with Onat and Gul's (2018) findings and with Webb and Cutter's (2009) argument that the spatial strategies of terrorism have shifted towards places of everyday activity. This seems to be the case with more recent attacks inspired by ISIS who have targeted highly populous public spaces. Further research should examine the level of risk each factor poses according to temporal variables. For example, it is likely that areas dense with shops are more likely to targeted during the day and at weekends, and areas dense with pubs and bars more likely to be targeted in the evenings. As the period studied spans 10 years, it could be argued that the infrastructure underwent some changes during this time. However, Caplan, Kennedy and Miller (2011) argue that generally infrastructure is stable over time.

Restaurants and cafes, protestant churches, sports clubs, transport hubs and arms finds were not significant correlates of bombings or bomb hoaxes. VDRs are known to attack along the railway lines (Horgan and Morrison, 2011), however

it was not possible to add the length of the lines onto the RTM. Government buildings may have a high level of security and therefore deter attacks, with the actors preferring more populous areas with less security measures.

It would have been preferable to examine the effects of residential segregation in more detail. However, the only religious data that could be obtained was for 'Small Area' (SA) level. As there is a high degree of variation in the land area that SAs cover it was deemed inappropriate to use the centroids of majority Catholic or Protestant areas as a risk factor. If grid square level data was obtainable, this could have been a useful addition to the model, although the land area that each grid square covers (typically $1km^2$) is likely to have been too large to establish a meaningful connection.

Only one city was modelled and one ideology studied, therefore it may not be appropriate to generalise these findings. The results of the models suggest that risk terrain modelling could be an important tool in the policing of terrorist events in Northern Ireland. Although they may have limited applicability to other regions, some of the findings may also be valid in other contexts. For example, the finding that populous areas such as places dense with pubs, bars and shops are significant correlates of attacks may hold in other cities, and future research should endeavour to study this. Until this is established, it should not be assumed that the results of this RTM can be applied across all environments. Some of the risk factors that were identified were a unique combination of VDR ideology and Northern Irish culture, and so the risk factors identified may be specific to the spatial and situational contexts of VDR activity. Further, as with all open source data, there is always the possibility that the locations of some events were not recorded accurately, and as such the distances from the risk factors could be under or over estimated.

5.6   Conclusion

The mode of analysis applied in this chapter could be a useful tool in guiding targeted responses to the VDR threat in Belfast. It has identified specific areas that are likely to be more vulnerable to attacks than elsewhere in the city and should therefore be prioritised in security measures. Other known activity of the group, symbolic buildings and populous areas were all found to be correlates of terrorist incidents. This has important implications for the policing of terrorism in Belfast, and has the potential to be applied to other cities within Northern Ireland. Extra resources could be deployed to the areas identified as being high risk when necessary, and target hardening could be implemented in these areas. It should not be assumed that all areas which were identified as being high risk will be targeted. If any interventions are implemented there is the possibility for displacement of incidents. However, as this type of model identifies the key correlates of the hotspots, rather than solely their location, other possible future locations that could potentially be at risk can be identified.

Thus far, this thesis has used offender (chapter 3) or target (chapters 4 and 5) based approaches to study target selection. Offender based studies that focus on the journey-to-crime are limited, as distance is treated as the dependent variable. This assumes that possible targets are spatially uniformly distributed. Target based approaches, such as the decision-making process in 'who' or 'what' is targeted (for example the factors involved in leading a terrorist group to attack civilians), are also constrained. Although the specific target attributes can be examined and choice criteria can be established, information regarding the offender is often disregarded. By ignoring the home locations of the offenders this approach assumes that geographical proximity has no influence on attacks or that the spatial distribution of offenders' homes is equally spaced. The next chapter uses discrete choice modelling to overcome these limitations, through an analysis of attacks by the Provisional Irish Republican Army.

Chapter 6   Modelling the spatial decision making of PIRA: the discrete choice approach.

6.1   Introduction

Terrorists are rational decision-makers (Clarke and Newman, 2006). Much like ordinary criminals, they make a series of cost-benefit analyses to judge whether a particular act is worth committing (Gill et al., 2018). Their rationality is bounded by a number of individual factors such as risk sensitivity, group guidance, prior experience, and personality. Geographical proximity is an additional factor which has received some empirical support lately (Gill et al., 2017; Marchment et al., 2018). In treating distance as a dependent variable however, such studies are limited. They assume targets are spatially *uniformly distributed*. The potential targets that could have been chosen, but were not, are overlooked. Ideally, distance should be treated as an *explanatory* variable, rather than the dependent variable (Kleemans, 1996) and should be used alongside other choice criteria, such as the connectedness of the area, to determine why the chosen target was selected above other similar targets (Bernaso and Block, 2009).

To overcome similar limitations to those mentioned above, Bernasco and Nieuwbeerta (2005) applied McFadden's (1974) discrete choice model to the spatial-decision making of burglars. Stemming from the field of economics, this approach allows target selection analyses to simultaneously consider multiple factors including the chosen target destination, areas that could have been chosen but were not, the likely origin of offenders and their perceptions that affect decision making. This approach is now well-established in the study of a variety of urban crimes, however is yet to be applied to terrorism.

This study applies the discrete choice model to 150 attacks committed by core members of the Provisional Irish Republican Army (hereafter, PIRA). PIRA's attacks were often dependent on the decision making of the individual and were

not carried out unless there was a high probability of success (Horgan and Taylor, 1997). The longevity of their campaign, and the variety of attacks incorporated throughout, also provides a wide scope for data. The results suggest that terrorists are similar to traditional criminals in their decision making and they are influenced by spatial context, such as the distance from their home location to the attack location, or the presence of a premises relevant to their ideology.

6.2 Theory

Collectively, rational choice perspectives, routine activity theory and crime pattern theory, as discussed in chapter 2, suggest offenders actively select areas and targets in a way that minimises effort and risks and maximises rewards (Johnson and Bowers, 2004; Felson, 2006). Research suggests that a multistage hierarchical process in decision making occurs, whereby offenders select an area that is deemed suitable for the offence, before selecting the specific target (Brantingham, 1978; Brown and Altman, 1981; Wright et al., 1995; Bernasco and Nieuwbeerta, 2005). The discrete choice approach (McFadden, 1974) can be used to model an individual's choice between a set of two or more discrete alternatives. This is based on the utility they expect to derive from each alternative (Train, 2003). It is assumed that the terrorist's choice is the one that offers the best perceived utility, based on expected rewards, risks and effort. When applied to crime, the approach allows target selection to be analysed by considering multiple factors at the same time, and enables an impedance measure of distance to be treated as an explanatory variable. As well as the location that was selected for an attack, the model also allows for areas that were not chosen to be examined simultaneously, as well as also considering the origin of offender, and other defined factors that may affect decision making (Bernasco and Nieuwbeerta, 2005).

The approach was first applied in environmental criminology by Bernasco and Nieuwbeerta's (2005) study of residential burglaries. As well as confirming the

importance of proximity in target selection, this framework was the first step in establishing risk factors for burglary that were reliant on specific offender characteristics (Bernasco and Nieuwbeerta, 2005). This residential burglary study has since been extended upon with different sample sizes, types of offenders, areal units and independent variables (Bernasco 2006; Bernasco and Kooistra, 2010; Bernasco, 2010; Townsley et al., 2016). High house values for the area increased the likelihood that the area would be chosen (Bernasco and Kooistra, 2010), and a more recent area of residence was more likely to be selected than a less recent area of residence (Bernasco, 2010).

Since its introduction into the study of crime, the discrete choice model has also been used to identify factors (including crime generators and crime attractors) that can increase the likelihood of an area being chosen as a target for residential burglaries in other cities (Townsley et al., 2015; Vandeviver et al., 2015; Frith et al., 2017), street robberies (Bernaso and Block 2009; Bernasco et al., 2013; Bernasco et al., 2013), commercial robberies (Bernasco and Kooistra, 2010) and thefts from vehicles (Johnson and Summers, 2015). Ethnic dissimilarity to the offender decreased the likelihood that an area would be selected for street robberies (Bernasco and Block, 2009; 2011). If an offender had previously lived in an area it increased the likelihood that they would select it for a commercial robbery (Bernasco and Kooistra, 2010). Areas low in social cohesion were preferred by offenders committing thefts from vehicles, and areas that contained schools were favoured by juvenile offenders (Johnson and Summers, 2015).

Clare et al. (2009) expanded on previous studies by exploring the role of natural barriers and connectors on location choice for residential burglaries in Perth. They found the presence of physical barriers such as rivers and roads between the home and target locations significantly reduced the likelihood that the area would be chosen. Connectors, such as the presence of a train line in both the home and target location, increased the likelihood that the area would be chosen. Johnson and Summers (2015) also found that areas more connected by major roads were favoured by adult offenders for thefts from vehicles. Similarly, Bernasco, Block and Ruiter (2013) found offenders committing street robbery

were more likely to attack in areas that were easily accessible and contained legal or illegal cash economies.

More recently, Menting et al. (2016) used the discrete choice model to examine the effects of the offenders' family members' homes on crime location choice. They found the residential areas of the offender's family members were more likely to be targeted, most likely due to the increased familiarity with the area as it becomes part of their awareness space. Bernasco et al. (2017) added a temporal element by using separate discrete choice models for every 2-hour time block per day, for every day of the week, to examine street robbery in Chicago. They concluded that the time of day or week does not affect the importance of defined attributes. For example, robbers preferred to operate in areas close to transit hubs and cash economies, regardless of population density at the time. Lammers (2017) examined the influence of co-offending on crime location choice in The Hague, with results indicating a preference for areas known to multiple members of the group (a shared awareness space). This framework is now well established in studies pertaining to traditional urban crimes. It has also been applied to infrequent extreme events such as rioting (Baudains et al., 2013). There, the presence of an underground train station increased the likelihood the area would be chosen as well as the volume of retail outlets (and therefore number of potential targets).

However, to the best of our knowledge, the discrete choice model is yet to be applied to terrorism. The literature suggests terrorists are rational and purposeful in their decision making. Terrorists make carefully calculated decisions that are utility maximising (Asal et al., 2009) and likely to increase their probability of success (Hoffman, 2006; Clarke and Newman, 2006). When considering the operations of PIRA, it is evident that target selection was guided by the decision making of individuals living within the locality, due to their increased familiarity with the operational area (Gill and Horgan, 2013; Johnson et al., 2013; Asal et al., 2015; Gill et al, 2017; Gill et al, 2018). PIRA members often operated with a high degree of autonomy. Even when high-profile operations were ordered from the top-down, the target selection was likely to have been guided by the attacker's

original intelligence-gathering on that target (Horgan and Taylor, 1997). PIRA member Eamon Collins reported that he "*never stopped looking for military targets.*" Gerry Bradley's account of life in PIRA describes attacks as "*pure spur-of-the-moment ... target of opportunity.*" Brendan Hughes recalls noticing a British Army jeep nearby: "*We were so confident and in such control of the area at that time that instinct took over: 'There's a target' and 'Hit it.'*" PIRA attacks were only carried out if there was a high probability that the attack would be a success (Horgan and Taylor, 1997).

As this model of target selection is a model of choice, the decision criteria that shape the choices of offenders should be defined, as well as the specification of the set of alternatives that the actors can choose from. A terrorist's decision making process is bounded by incomplete information. Although their knowledge is bounded, they are essentially choosing between every premise and person in the city, presenting an enormous choice set. However, the idea there is a hierarchical process in decision making, as mentioned above, suggests the choice set for any offender is a limited number of areas. These can be defined using spatial units such as suburbs, wards or output areas. In this case, the set of alternatives takes the form of output areas called 'small areas' in Belfast, Northern Ireland and the expected utility of each potential target area is assumed to be evaluated according to the decision criteria presented below.

6.3 Decision Criteria

The following subsections, a) distance; b) natural barriers and c) ideology, consider the theories presented above as well as previous empirical research. In a broad sense, they are based on the assumption that the offender will act rationally in spatial decision making, considering the associated risks, rewards and efforts when selecting areas to target.

6.3.1 Distance

The least effort principle (Zipf, 1965) assumes that when considering a "number of identical alternatives for action, an offender selects the one closest to him in order to minimize the effort involved" (Lundrigan and Czarnomski, 2006, p.220). Typically, an offender's journey to crime demonstrates the distance decay function, whereby chances of offending and frequency of offences decrease as distance from their home increases (Wiles and Costello, 2000; Bernasco and Block, 2009). To increase the utility of their attack the offender would aim to keep the distance travelled minimal (Clarke and Newman, 2006). As well as considering effort, the risk of interception before an attack should also be taken into consideration (Townsley et al., 2008). The function of distance decay has been empirically supported when examining the activities of PIRA (Gill et al., 2016), and the effect has been replicated for lone actors (Marchment, Bouhana and Gill, 2018). Due to their familiarity with the area, PIRA members often operated within their own 'locality' (Horgan and Taylor, 1997). Further, PIRA members were often under time constraints, for example due to work and/or family commitments, and as such they would limit the distance they would travel when offending (Gill et al., 2017). As such, it is hypothesised:

H1: The closer a potential target area to an actor's home, the more likely it is that it will be selected.

Similarly, it is also likely that areas in the individual's awareness space identified through their daily routines will be targeted. It is likely that the city centre will be more familiar to the offender than other areas of the city, as they are more likely to be regularly frequented due to the amount of facilities available (i.e. transport, entertainment, retail establishments) (Bernasco and Nieuwbeerta, 2005, Bernasco and Block, 2009). Johnson and Summers (2015) found that adult offenders exhibited a preference of offending close to the city centre when considering thefts from vehicles. It is therefore hypothesised:

H2: The closer a potential target area to the city centre, the more likely it is that it will be selected.

6.3.2 Natural barriers

The movement of an individual is not random and can be bounded by physical and social constraints. Brantingham and Brantingham (2003; 2008) propose that natural features such as rivers and forests act as natural 'barriers'. These barriers restrict the movements of offenders and the resulting effort required to offend beyond them is increased. When examining effects of the physical environment on burglary locations, Clare et al. (2009) found a decreased likelihood that a potential target area beyond a natural barrier would be selected. When examining target choices of the August 2011 London riots, Baudains et al. (2013) found that individuals were up to five times more likely to select an area that was on the same side of the river Thames as their home. When taking into consideration that the city of Belfast is split by the River Lagan, and that this will impede the movement of the offenders, it can be suggested that:

H3: The presence of a water body between the actor's home and a target area will reduce the likelihood that the area will be targeted.

A logical suggestion for why one area is chosen over another is accessibility. It is likely that areas that are more connected to other parts of the city will experience more attacks than those that are not. For example, the existence of a major thoroughfare in the area may influence the likelihood of an area being chosen. As major roads facilitate travel around the city, they are likely to be travelled on more often than other smaller streets, such as cul-de-sacs. Thus, an individual's familiarity with the area surrounding major thoroughfares is increased (Armitage, 2007). Similar previous research into burglaries suggests that the risk is higher in places that are more connected to others (Johnson & Bowers, 2010; Armitage, 2007). Similarly, Ozer and Akbas (2011) suggest the reason one of the major police stations in Istanbul is targeted by terrorists is because this station is connected by major streets. As well as ease of access, more connected areas also offer ease of escape (Berman and Laitin, 2008). Horgan and Taylor (1997) note "escape route accessibility" as one of the key considerations of PIRA members during the planning stage of their attacks.

H4: The presence of a major thoroughfare in an area will increase the likelihood it will be targeted.

6.3.3 Ideology

When considering that acts of terrorism are "designed to communicate a message" (Hoffman, 2006), it can be assumed that the spatial decision making of an individual regarding target selection will be influenced by interpretation of ideology[25] in some way. Clear differences have been demonstrated in the target patterning of PIRA when compared with their loyalist opposition, who were operating in the same social and geographical environment. This suggests that their differing ideologies may have played some part (Drake, 1998). Decisions regarding where to target are likely to be influenced by the availability of "good" and "suitable" targets. Under the assumption that terrorists are rational actors, it can be argued that their target choices will be governed by ideology and reflective of the greatest benefit for their cause (Drake, 1998), as acts of terrorism are designed to elicit a response from their target audience (O'Neill, 2005). Furthermore, attacks should be tailored to concur with their ideological framework, in order to maintain support from those sympathetic to the cause (Hoffman, 2006).

Rewards may be dependent on the availability of suitable victims. Specific structures will increase the attractiveness of the area, as the likelihood that a suitable target is present will increase. PIRA's ultimate aim of ending British rule in Northern Ireland by inflicting enough casualties on British forces that they would be forced to withdraw meant that any member of the security forces was seen as a legitimate target (Drake, 1998). It is expected that buildings representative of a British presence in Belfast will act as crime attractors, due to the availability of suitable targets, i.e. individuals entering and leaving the premises, as well as the premises themselves. It is also suggested that those

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[25] Defined as "beliefs, values, principles, and objectives – however ill-defined or tenuous - by which a group defines its distinctive political identity and aims… and provides a motive and framework for action" (Drake, 1998: 2-3).

chosen will be in the awareness space of the individual (Baudains et al., 2013). When considering traditional crimes, it is likely the presence of a police station would act as a crime detractor and an offender would avoid that area to reduce the risk of detection. However, when considering PIRA's ideology, it can be argued that the opposite may be true, due to the availability of targets. As such, the following is formulated:

H5: The presence of a British military base, an Irish military base, or a police station will increase the likelihood that the area will be targeted.

6.4 Data and Analytical Strategy

6.4.1 Geographical domain

To test the hypotheses, data were used pertaining to attacks by members of PIRA, living in the city of Belfast, Northern Ireland, in the period 1969-1989. This period encompasses the first three of five distinct phases of PIRA activity (Gill et al., 2014). Belfast is the capital and largest city of Northern Ireland and is on the flood plain of the River Lagan. The city of Belfast was chosen for this chapter as The Belfast Brigade was the largest of PIRA's command areas, and as such a substantial amount of PIRA activity occurred in the city.

Since 2011, Northern Ireland has been divided into 4537 'Small Areas' (hereafter, SAs), which are currently the smallest areal unit. [26] SAs were designed specifically for statistical purposes and follow physical features of the environment such as roads and rivers (Northern Ireland Statistics and Research Agency (NISRA)). As no sociodemographic variables were included in the analysis, it was deemed that SAs would be appropriate to use, and they therefore

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[26] Wards were the smallest geographical unit in Northern Ireland during the period studied (and were revised twice during this time). However, the area that each ward covered was quite large (mean area 2.25km^2) and as such it was likely that the effects of some of the variables may be wrongly estimated. For example, most of the wards in Belfast contained a major road and/or a police station, and the effect of distance was one of the key variables to be examined.

formed the choice set of alternatives for this study (a total of 890 for Belfast). The geographical boundary data for the SAs was obtained from NISRA.

6.4.2 Case Selection

The final offence and offender datasets comprised 150 attacks by 127 PIRA members within Belfast.[27] The datasets were created using parts of an existing dataset (n=92 members) previously used for a social network analysis of PIRA's active core members (Gill et al., 2013), as well as additional data obtained from The Irish Times newspaper archives (n=58 members). The full original dataset (Gill et al., 2013) contained 1240 members of PIRA. The individuals were identified from a number of open-sources: a) statements by the Irish Republican Army; b) the Belfast Graves publication (an account of Republicans killed in combat); c) McKittrick et al.'s (2001) "Lost Lives" which provides an obituary of each civilian and paramilitary victim of the Northern Ireland conflict; d) historical accounts of PIRA from academic sources; and e) newspaper archives. Core members included those individuals who had conducted attacks on behalf of PIRA whilst also holding central positions within the organisation, or at one point in time, co-offended alongside those who held central positions within PIRA. Of these, 139 were convicted of planting bombs and 103 were convicted of shootings (total of 239) in Northern Ireland. To qualify for inclusion in the offence dataset, the attack had to be attempted or committed by a member residing in Belfast, between 1970 and 1989 (n=97). Cases were removed from the dataset if an accurate home location could not be ascertained (n=2). Cases were also removed if the home location of the actor was outside of the study area (n=3), in line with previous studies (Bernasco & Luykx, 2003; Bernasco, 2006, 2010; Bernasco & Block, 2009, 2011; Clare et al., 2009; Bernasco et al., 2013), as the model requires all alternatives in the choice set to be computed. This resulted in a total of 92 incidents.

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[27] To account for reoffending, and to avoid disproportionate influence on parameter estimation, robust standard errors (SE) were used (Bernasco and Nieuwbeerta, 2005; Johnson and Summers, 2014).

Following this, the full archives of The Irish Times were systematically searched for convictions of core members of PIRA using the same inclusion criteria. This resulted in 58 additional cases for inclusion.

The location of each attack was geocoded to the corresponding SA. A direct link had to be made with the member of PIRA who committed the attack, whose home address at the time of the attack was known, to qualify for inclusion. The offender dataset contained information on the offender's home location (also geocoded to SA).

Figure 6.1. Thematic map of home locations of offenders per SA in Belfast (1969-89)
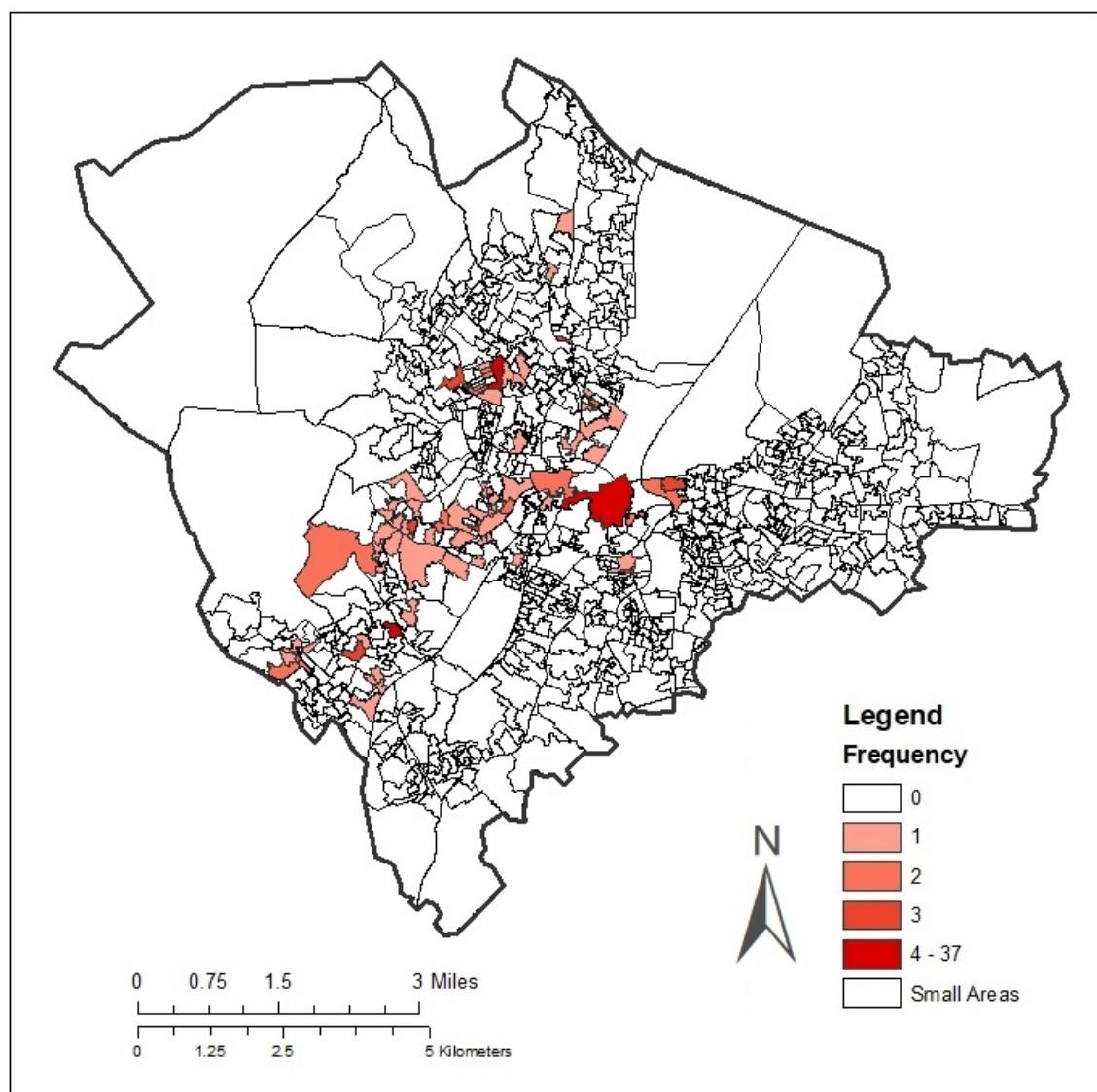
Figure 6.2. Thematic map of attacks per SA in Belfast (1969-89)
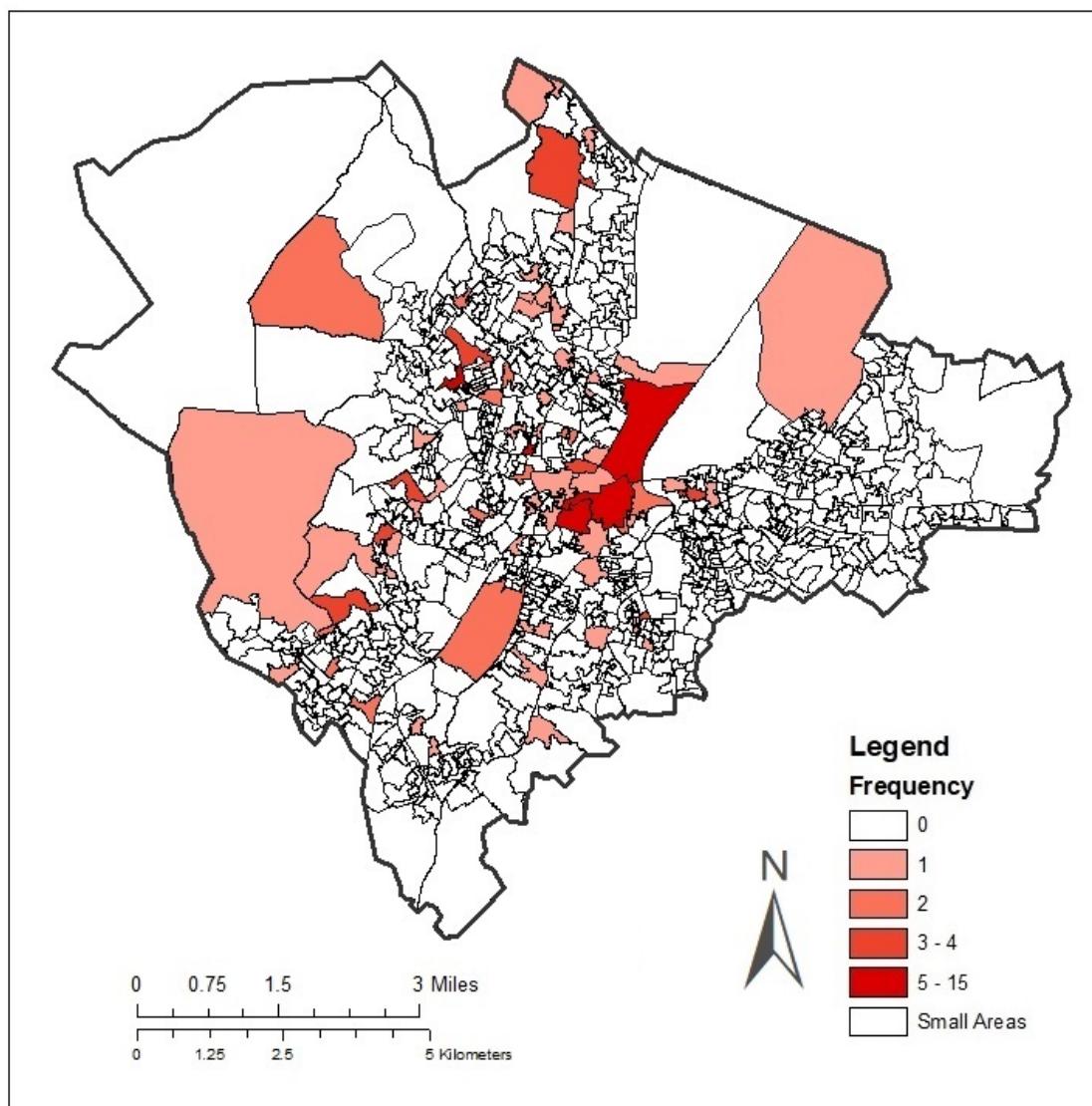
6.4.3 Small Area Characteristics

Various sources were used to operationalize the characteristics of each SA as well as other decision criteria. The geographical SA data was obtained from the Northern Ireland Statistics and Research Agency (NISRA). Binary indicator variables were used to identify the presence of major thoroughfares (A-roads - as according to the Ordnance Survey of Northern Ireland), military bases and police stations (both identified using the Conflict and Politics in Northern Ireland web service (CAIN) during the period studied. Distance from the city centre was calculated as the distance from each centroid to the centre of Belfast (measured as a *point* in the Central Business District) in kilometres, and Ghosh distance was used in cases where the city centre was located in the same SA as the home SA (please see below for a more thorough explanation of these measures). Attacks were clustered at SA level: 7 SAs (out of 890) accounted for a third of all attacks for this period.

Table 6.1. Summary statistics of the independent variables used to characterise the SAs

Variable	Description	Mean	Standard Deviation	Min	Max
Distance to the city centre	*Measured in km*	3.88	1.97	0.28	10.37
River Lagan	*Binary indicator for whether the SA is east or west of the river (same or opposite side to the home SA)*	0.73	0.45	0	1
Major roads	*Binary indicator for whether there is a major road (A-road) in an area*	0.27	0.57	0	1
Military base /police station	*Binary indicator for whether there is a military base or a police station in an area*	0.03	0.16	0	1

6.4.4 Small Area to Small Area Characteristics

These dyad level measures reflect the relationship between the home location of the actor and the target location of the attack and are used to measure impedance and barrier variables between two SAs.

Distance Measures

In line with previous research, the Euclidean distance was computed between the offender's home location and each potential target area. Although the exact home and target locations of each attack were known, the model requires the distance to all non-selected areas to be calculated as well as the ones that were chosen as targets. Consequently, to keep measurement errors consistent, the distances to selected and non-selected SAs were calculated in the same way, using the geometrical centroids of each SA (Bernasco, 2006). An origin-destination distance matrix was created which defined the distance between the geometrical centroids of each SA and the city centre. In line with previous studies, in cases where the origin and destination were located in the same SA (and therefore representing a zero value on the diagonal of the distance matrix) the Ghosh (1951) distance was used. This distance measure calculates the average distance between two points in a polygon using the formula $D_{ii} = \frac{1}{2}\sqrt{O}$, where O is the area of the SA in square kilometres (Ghosh, 1951; Bernasco and Nieuwbeerta, 2005; Bernasco, 2006). Consistent with previous studies, the distance decay function of crime trips is clear (see figure 3).

Binary Variables

Binary indicator variables were used to identify the presence of the following: a) the river Lagan, and as such determining a natural division between the offender's home SA and target SA); b) a British army base, Irish army base or police station; and c) a major thoroughfare.

6.4.5 Discrete Choice Model

The discrete spatial choice approach concerns an individual's choice between a set of two or more discrete alternatives, based on the utility they expect to derive from each alternative (Train, 2003). In this case, the set of alternatives takes the form of SAs in Belfast, Northern Ireland and the expected utility of each potential target area is assumed to be evaluated according to the decision criteria presented above. It is assumed that the alternative the terrorist actor chooses is the one that offers the best perceived utility, based on expected rewards, risks and effort.

This is specified as:

$$U_{ij} = \beta\, Z_{ij} + e_{ij}$$

whereby Z_{ij} is representative of the perceived utility of the actor i from choosing alternative j. β is the attribute coefficient that is empirically estimated from patterns in the data. As the information for the observer is limited e_{ij} is a random error term representative of any unobserved additional factors (i.e. personal preferences and other idiosyncrasies of the terrorist actor) that are not included in the model but may affect perceived utility.

It is assumed that an actor (i) will choose the alternative (j) if it gives them more utility than the others (k):

$$Z_i = j \quad \textbf{if} \quad U_{ij} > U_{ik}, \; \forall \; k \neq j$$

where Z_i represents the choice made by actor i. Under the assumption that the j disturbances are independently and identically distributed with type 1 extreme

Gumbel distributions, the appropriate statistical analysis to test the hypotheses of this study is the conditional logit model[28], which takes the form of:

$$Z_{ij} = \sum_{m=1}^{M} \beta_m \, X_{mij}$$

where *M* is the number of characteristics associated with the utility, corresponding to the total number of variables captured at the area level. X_{mij} is the value measured for attribute *m* for the actor *i* choosing to select a target in area *j*.

The probability that the actor will choose area j is given by:

$$P(Y_i = j) = \frac{\exp(Z_{ij})}{\sum_{k=1}^{J} \exp(Z_{ik})}$$

$$= \frac{\exp(\beta_1 \, X_{1ij} + \beta_2 \, X_{2ij} + \cdots + \beta_M \, X_{Mij})}{\sum_{k=1}^{J} exp\,(\beta_1 \, X_{1ik} + \beta_2 \, X_{2ik} + \cdots + \beta_M X_{Mik})}$$

where J is the number of areas for the actor to choose between.

The values of *βm* are estimated using maximum likelihood estimation and are interpreted as the multiplicative effects of a one unit increase in a SA's attribute on its probability of being selected by actor *i*. A *βm* value equal to 1 is representative of no association between the variable and the decision making of the actor, with values above 1 suggesting that the variable is positively associated with the likelihood of a SA being chosen.

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[28] The conditional logit model is used as it incorporates attributes of both the alternatives and the individual (terrorist) actors. This is opposed to the multinomial logit model which only considers the attributes of the actors.

6.4.6 Conditional Logit

The conditional logit model was applied to test the hypotheses of this study: all models were estimated using STATA (StataCorp, College Station, TX). To implement the model a final working dataset was created in which every possible alternative SA (N = 890) was listed for every individual attack (N = 150), resulting in a 133,500-record matrix. The dependent variable for the conditional logit estimation procedure takes the form of an indicator variable, used in this study to identify the chosen target SA of each offender for each attack. A value of 1 is representative of the chosen SA, values of 0 used for the other 889 SAs that were not chosen. Model fits were assessed and compared using McFadden's Adjusted Pseudo-R^2 (McFadden, 1976): those with large R^2 values were considered better fitting. Pseudo R^2 values are typically much lower than those of ordinary regression analyses: values of 0.2-0.4 are considered extremely good for a conditional logit model (Domencich and McFadden, 1975; McFadden, 1976; Louviere et al., 2000).

6.5 Results

The results of the conditional logit model are presented in table 6.2. The $e\beta$ parameters in all results tables are representative of the multiplicative odds ratio of a target SA being selected, following an increase of one unit in the relevant variable.

Overall Model Fits

The model tested in this study provided a satisfactory level of fit, with a McFadden pseudo-R^2 value of 0.178. The likelihood-ratio test (p<0.001) of the model demonstrates that it fits the data better than the null model. Three of the parameters significantly contributed to the predictive capacity of the model.

The coefficient of the first distance parameter is in line with hypothesis 1. The results show that an increase in distance to the target SA from the home location

will decrease the likelihood that this SA will be chosen as a target (e^β = 0.61, p<.001). However, against the expectation of hypothesis 2, no significant effect was found for the distance from the city centre.

The estimated effects of a river acting as a natural barrier (hypothesis 3) were in the right direction, but not statistically significant (e^β = 0.72, p=.25). In line with hypothesis 4, the presence of a major road was associated with target choice, increasing the likelihood of the SA being chosen as a target by a factor of 1.77 (p<.001). As predicted, the presence of a military base or police station increased the likelihood that the area would be chosen as a target (e^β = 13.78, p<.001).

Table 6.2. Estimates of the conditional logit model

Variable	$e\beta$	z
Distance (km)	0.61***	-7.5
Distance to city centre (km)	1.02	0.21
River (Barrier)	0.72	-1.16
Major Road (Connectivity)	1.77***	8.95
Military Bases / Police stations	13.78***	15
McFadden's Adjusted Pseudo- R^2	0.143	

* p < 0.05 for $e\beta = 1$, one-tailed, ** p < 0.01 for $e\beta = 1$, one-tailed, *** p < 0.001 for $e\beta = 1$, one-tailed

Figure 6.3. Results for each variable of the conditional logit model
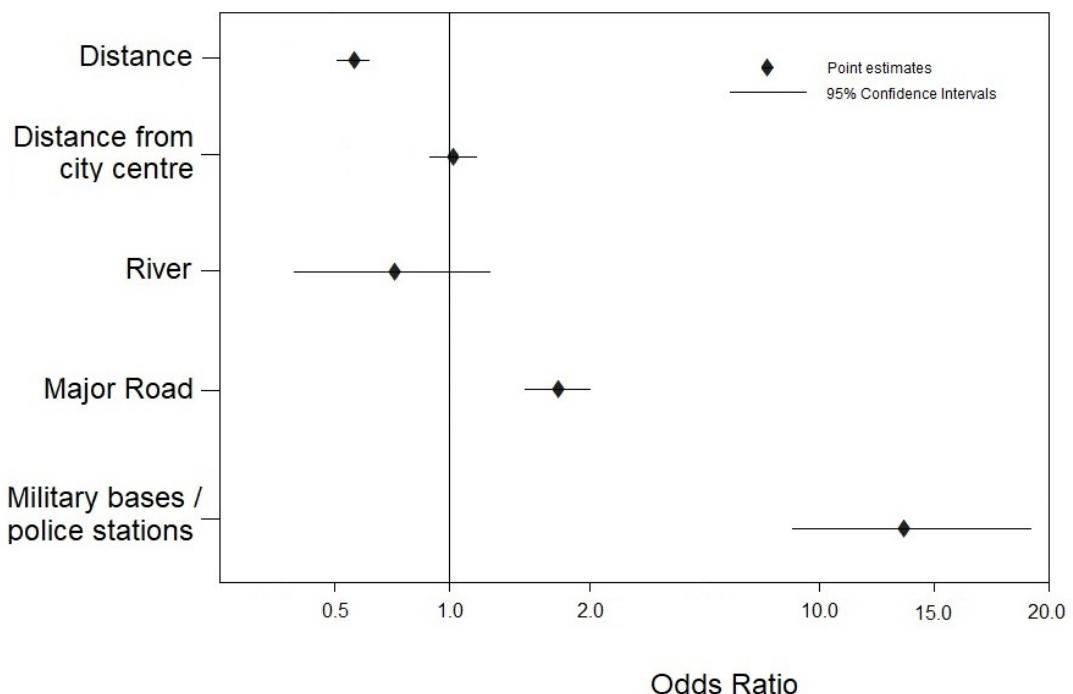
Table 6.3. Summary of findings according to hypotheses

No.	Hypothesis	Findings
1	*The closer a potential target area to an actor's home, the more likely it is that it will be selected.*	**Supported**
2	*The closer a potential target area to the city centre, the more likely it is that it will be selected.*	Not supported
3	*The presence of a water body between the actor's home and a target area will reduce the likelihood that the area will be targeted.*	Not supported
4	*The presence of a major thoroughfare in an area will increase the likelihood it will be targeted.*	**Supported**
5	*The presence of a British military base, an Irish military base or a police station will increase the likelihood that the area will be targeted.*	**Supported**

6.6 Discussion

Whilst there are some associated unavoidable caveats, this analysis provides a good starting point for further applications of the discrete choice approach to terrorist activity. The findings are very promising and provide further support that terrorist actors behave similarly to urban criminals in terms of spatial decision making when selecting targets. The results empirically demonstrate that the locations of attacks by PIRA were influenced by characteristics of the target SAs as well as the properties of their likely journey to the target. The main model indicated that three of the variables affected the likelihood of a SA being chosen as a target. An increase in distance from the home location decreased the likelihood that the SA would be chosen. The presence of a major road in the SA also increased the likelihood that the SA would be selected, as did the presence of a military base or police station.

Distance is highlighted as an important factor in target selection, which is consistent with previous studies of terrorist activity (Clarke and Newman, 2006; Gill et al., 2017) and traditional criminological studies (Wiles and Costello, 2000; Bernasco and Block, 2009). The results illustrate the impact of distance decay, with actors less likely to select an area as distance from the home increases, most likely due to the changes in required effort. This provides further empirical evidence that the target location choice of terrorists is affected by required effort, and that, like traditional criminals, terrorists are limited by geographical constraints. The identifiable effects of the distance variables could be extremely beneficial for investigative techniques, especially when a threat is made against a specific target (Gill et al., 2017).

Something that could be taken into consideration in future analyses is the mode of transport to and from each attack. Travelling on foot yields higher risk than by car and it is likely that the actors would stay closer to home. Travelling to more distant areas on foot would also be much more time consuming, and could increase the risk of identification and apprehension (Bernasco and Block, 2009). It is likely that the actors would have travelled by car when attacking premises as

the majority of these attacks were bombings and arson attacks; in particular the use of car bombs during the mid 1970s was extremely high (Horgan and Taylor, 1997).

Contrary to expectations, an association between target selection and distance from the city centre was not supported. This goes against previous research and the suggestion that SAs closer to the city centre will be selected due to an actor's familiarity with the area (Bernasco and Nieuwbeerta, 2005; Bernasco and Block, 2009). However, as highlighted by Johnson and Summers (2015), it should be noted that the distance of the target location from the city centre is analysed independently of how far the attacker's home location is from the city centre. It is likely that their homes were in residential areas away from the city centre and the results confirm that the actors were more likely to commit attacks very close to their homes. The mean distance between home addresses and the city centre was 3.08km.

No support was found for the notion that rivers can act as physical 'barriers', which contrasts with previous research (Brantingham and Brantingham, 2003; Clare et al., 2009). As Euclidean distance was used, it could be argued that the true distances between SAs on either side of the river may be underestimated. There are only a few points to cross the river via road, which would have influenced the results of a street network approach to the analyses, and may have revealed support for this hypothesis. Further research should explore this.

The presence of a military base or police station increased the likelihood of a SA being targeted. This is in line with optimal foraging theory, and the hypothesis that certain premises would increase the likelihood of an attack due to the availability of targets in the surrounding areas, i.e. officers travelling to and from work. However, caution must be taken when considering this outcome. It may be that attacks near to police stations or military bases were more likely to have been detected, and as such the identity of the offender is more likely to be known. When a sample of attacks is used where it is necessary to have both the home and attack locations, this may be over-represented in the data. However, after

plotting a dataset of all attacks where a street address could be found (regardless of whether the home location was known), it was found that SAs experienced similar proportions of attacks.

Regarding connectivity, and consistent with the findings of Ozer and Akbas (2011), the presence of a major thoroughfare increased the likelihood of an area being chosen. This suggests that ease of access and escape are important when selecting targets (Stohl, 1998). These variables are also analogous with the offender's likely familiarity of the area (Armitage, 2007; Johnson and Bowers, 2010) which further highlights the importance of an individual's awareness space (Bernasco and Nieuwbeerta, 2005).

As with many quantitative studies of terrorism and political violence there are a number of constraints associated with the data used in this study, and possible caveats are acknowledged. Some difficulties were encountered due to the historical nature of the records used. Typically, similar studies that implement this model to traditional crimes also analyse social context factors in order to further examine environmental criminological theories. For example, levels of social disorganisation (Shaw and McKay, 1942) can be used to assess the degree to which residents of an area can affect informal social control (Bernasco and Nieuwbeerta, 2005; Clare et al., 2009). It was not possible to test the function of some factors that have previously been tested in traditional criminological papers, such as the effects of affluence and social disorganisation, as appropriate figures were not available.

The author initially wanted to consider the residential segregation of Catholics and Protestants in Northern Ireland in this paper. The separation of the two religious communities is a key characteristic of Northern Irish society that has helped in the understanding of many aspects of the conflict (Cairns, 1982; Hewstone et al., 2006). When optimal foraging theory is taken into consideration it is unlikely that members of the predominantly Catholic PIRA would have frequented areas dominated by the Protestant opposition (Hughes et al., 2008). These areas would not be in the offender's cognitive awareness space and as

such they would have limited knowledge about the inhabitants (Brantingham and Brantingham, 1981) and physical infrastructure (Bernasco and Nieuwbeerta, 2005).

Bloom (2005) proposes that Palestinian groups chose individuals to carry out attacks who had features that would fit in with Israeli society. Carter and Hill (1979) found that, in the case of extremely segregated cities, an individual's mental image of their city is often incomplete and strongly influenced by their racial background, due to the dangers of offending where they cannot blend in easily. Bernaso, Block and Ruiter (2013) found that offenders committing street robberies in Chicago preferred areas where the majority of residents matched their own racial or ethnic background. Although this concept of 'standing out' in unknown territory is most obvious when considering race, the same affects may be reflected when considering religion. PIRA would be easily identifiable as the opposite side (Gill et al., 2017) and could be recognized as strangers to the area (Brown and Altman, 1981; Bernasco and Block, 2009). However, due to the retrospective nature of this study it was not possible to get this information for the period studied at small areas level. Some information was available at ward level, however the extent to which analyses at this level can provide meaningful information is limited, and the author deemed this level of aggregation to be too large. As a result, the decision was made to exclude potential social context variables. This meant that it was possible to use a smaller areal unit and therefore increase the potential utility for practitioners.

This is a complete analysis of *core* Belfast PIRA members convicted of an attack where both the home and attack locations are known. It is a comprehensive dataset for the city with respect to the most important and highly connected members of PIRA (Gill et al., 2014). However, it is not a complete dataset of all PIRA activity in Belfast during this period as several attacks that were identified from the Irish Times archive had to be excluded from the dataset. The main reason for this was because they could not be directly attributed to a specific individual. Also, due to the underlying mechanisms of this model, the data had to be restricted to one city. It was also necessary to omit attacks in Belfast

committed by non-residents and incidents outside of Belfast committed by Belfast residents from the sample, thus the effects of the distance variables may be underestimated. This dataset is a slightly smaller sample in comparison to most previous similar studies of crime. There may be some parameter inflation and there is the possibility of skewing of distributions to values higher than the true odds ratio. However, Baudains et al (2013) used a similar sample size in one of their models in their study of the five days of rioting in London. They also noted that although they excluded two of the days (with sample sizes of 54 and 90) the parameter estimates were consistent with the other three days that were examined. Although the sample used in this study was deemed sufficient for the implementation of the model (Greenland et al., 2000), utilisation of a larger sample size would have been preferable. As well as improving the power and reliability of the model, a larger dataset would have enabled further hypothesis testing.

Areal unit boundaries are arbitrary and lack ecological meaning (Bursik, 1986) and the characteristic data used may not be an accurate representation of the perceptions of those living in the areas (Coulton et al., 2001). Smaller units would enable factors such as the effects of social disorganisation to be touched upon, if the data was available. The theoretical notions apply to much smaller units and the street block is the most appropriate unit for analysis (Taylor, 1997). However, larger areal units such as small areas relax the effects of independence of irrelevant alternatives (IIA) which is a consideration of the conditional logit estimation. The IIA assumption expresses that if someone is choosing among a set of alternatives, their odds of choosing *A* over *B* should not be affected by the presence or absence of an alternative *C*. When using larger units preferences for a choice will be less influenced by the inclusion or exclusion of other alternatives, thus affecting the ratios of β[29] estimates (Greene, 1997).

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[29] The attribute coefficient that is empirically estimated from patterns in the data.

As well as the necessity of replicating this study using other cities in Northern Ireland where PIRA were in operation, further studies should examine different terrorist groups to identify how transferable the effects are to different contexts. A good comparison would be another separatist organisation with similar targeting patterns, for example Euskadi Ta Askatasuna (ETA). ETA has repeatedly targeted the Guardia Civil (Civil Guard) and the majority of attacks are focused on military and police personnel as well as political and economic targets (Drake, 1998; Barros, 2003). Groups with different ideologies should also be studied, to increase the generalisability of the model.

There are several ways this study could be improved and expanded on through the further disaggregation of data. Initially, there was the aim to distinguish between different types of targets (i.e. attacks on premises and attacks on individuals); however, there was insufficient data to do so. Differences between males and females could be examined as well as modes of attack (bombings, shootings, arson etc.) and types of human target, i.e. military/government/civilian. Other models, such as a mixed logit (McFadden and Train, 2000) or latent class model, could be considered in future studies. The mixed logit also accounts for idiosyncratic variations to be examined, as it is likely that individuals place different emphases on certain attributes, for example distance (Robinson 1950). Disparities in the attacks of different terrorist actors could be looked at, in particular for PIRA where there were variations in the skill sets of members. Gill et al. (2017) found differences between different roles in the group (in this case shooters and IED planters), i.e. IED planters travelled longer distances to attacks. The use of a mixed logit or latent class model would also relax the effects of IIA.

Temporal variations are often neglected in criminological research (Ratcliffe, 2006). Using a model of spatiotemporal choice as opposed to spatial choice may demonstrate that certain types of attacks were more likely to occur on certain days of the week, or certain times of day (included in the set of alternatives), and improve the understanding of target selection. For example, PIRA tended to avoid attacks on Saturdays as there was no news on Sundays, and attacks were often tailored to fit in with the working and social schedules of members (Collins, 1998).

Terrorism is not static (Drake, 1998), and PIRA's structure and strategy underwent many changes throughout their campaign (Asal et al., 2013; Gill and Horgan, 2013). Future research could incorporate distinctions between the different phases of PIRA activity, to see if changes in strategy were reflected in variations in target patterning. It may also be interesting to examine differences between different groups in the same conflict. The effects of repeat and near repeat victimisation could also be taken into consideration. The use of this model to identify the effects of repeat and near-repeat patterns in terrorist attacks would be extremely useful in the anticipation of further attacks and prevention strategies. Studies of traditional crimes tell us that a crime event at one location increases the risk of a further event in the immediate vicinity and within a short time span (Johnson et al., 2007). This pattern has also been found when examining insurgent activity in Iraq (Townsley et al., 2008).

6.7 Conclusion

In summary, this study provides a very promising starting point for further applications of the discrete choice approach in terrorism studies. The results provide further support that decisions made by terrorist actors are guided by rationality, are similar to those made by traditional criminals, and are affected by associated risks and rewards. Future use of this model could play a key role in developing and implementing successful prevention and disruption measures.

Chapter 7   Conclusions

This chapter summarises the results of this thesis, addresses possible limitations and discusses ideas for future research. A general target selection framework (TRACK) is generated from the findings. This framework is then assessed using illustrative examples of recent attacks in the U.K.

7.1 Discussion of findings

The aim of this thesis was to gain a better understanding of the spatial decision making of terrorists when they are selecting targets, through the use of multiple methodologies and analyses. The results of each chapter collectively indicate that target selection is guided by an inherent logic, and that terrorists are rational in their spatial decision making. The findings of many previous studies of urban crime and terrorism were reflected in the results of this thesis, providing further support that paradigms of environmental criminology are relevant and useful in the analysis of terrorist threats. The insights into target selection are important for prevention and disruption efforts, and could be useful for policing and the allocation of resources in response to threats from lone-actor and dissident Republican terrorism. If any measures were to be implemented using the results of these analyses follow up studies would be necessary to assess their efficacy.

Chapter 3 presented the first empirical analysis of lone-actor terrorist journey-to-crime patterns in the U.S. and Western Europe. The results indicate that it may be appropriate to consider any findings regarding criminal and group-terrorist spatial decision making as relevant and applicable to right-wing and Islamist lone-actor terrorists. These types of lone actors behaved similarly to group actors and urban criminals by selecting targets in close proximity to their homes. However, single-issue lone actors may travel further due to a limited choice set of targets.

Chapter 4 offered the first spatial and temporal analysis of the current threat from violent dissident Republicans in Northern Ireland. It was demonstrated that, like urban crimes, attacks by VDRs in Belfast were spatially and temporally clustered. Attacks were more likely to occur in areas with a Catholic majority and in areas

in closer proximity to major roads. An incident was less likely to be followed by a subsequent attack within 4 days if the initial attack resulted in injuries or used a viable explosive device.

Chapter 5 sought to establish potential correlates of the hotspots that had been identified in chapter 4 through the use of risk terrain modelling. Areas in Belfast that may be more vulnerable to attacks than elsewhere in the city were identified. Other known activity of the group, symbolic buildings and populous areas were all found to be correlates of VDR incidents. These areas should therefore be prioritised in security measures. Extra resources could be deployed to the areas identified as being high risk and target hardening could be implemented in these areas. Differences were found between incident types. Police stations were identified as risky places for bomb hoaxes but not bombings. This difference could be explained by the perceived level of security at these premises and therefore increased likelihood of detection/reduced likelihood of success. As well as providing further support for the rationality of terrorists, this finding highlights the need to disaggregate data, and to avoid the treatment of terrorist incidents as one outcome variable.

Chapter 6 incorporated offender data through the use of a discrete choice approach. The results empirically demonstrated that the locations of attacks by PIRA were influenced by characteristics of the target areas as well as the properties of their likely journey to the target. The findings from this chapter provide further support that terrorists behave similarly to urban criminals in terms of spatial decision making when selecting targets.

7.2 Limitations

Although deemed sufficient for all analyses undertaken, a possible caveat of this thesis is the relatively small amount of data used in comparison to those typically used for studies of urban crimes. However, this is an unavoidable limitation in the field of terrorism studies, due to the clandestine nature of terrorist activity. The

samples used may also not be entirely representative of the phenomena studied as they are limited to the Western context. Terrorism is less frequent in Western countries than other areas of the world, such as the Middle East. Aside from practical data collection constraints (such as language barriers), the high frequency of attacks attracts a diminishing return on media attention on attacks in these areas and they are therefore under-reported. The results may be limited in generalisability, however, they do provide important insights for attacks in the U.K. The data used for lone actor attacks was not an extensive dataset[30], therefore it is inevitably subject to some bias. As with all open source data, there is always the possibility that the locations of some events were not recorded accurately, and as such the distances from the risk factors could be under or over estimated.

7.3 Recommendations for future research

Future work should endeavour to extend on the analyses using larger datasets if available, using samples from different countries and conflicts, and making comparisons across different terrorist groups. The variations in the facilitating conditions of the whole opportunity structure of terrorist incidents should be considered. Further temporal analyses should be incorporated where possible. For example, a discrete choice model of spatio-temporal choice, including factors such as day of the week and time of the day (as opposed to just spatial choice), could be used to advance our understanding of target selection. If closed source data were obtainable, it would be useful to identify similarities and differences in the target selection of successful attacks and attacks that were interdicted. One consideration that should be taken into account for this process is that actual targets often differ from intended targets.

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[30] Some cases had to be removed due to inaccurate home addresses.

It would have been preferable to analyse the findings of chapter 4 with the responses of police and counter terrorism strategies included (e.g. a comparison of locations pre and post a specific intervention). This data was unavailable for the current study, but, if possible, would be an important avenue to explore in future research.

A key area that has thus far been neglected and should be examined in future research is the spatial patterning of the residences of members of terrorist groups. The research surrounding involvement in terrorism intimates that there is a geographical dimension to recruitment and membership. Social network analysis has been used to study the structure of terrorist groups (Krebs, 2002; Jordan and Horsburgh, 2005; Clauset et al., 2008; Medina, 2011), and research has shown the biggest predictor of joining a terrorist group is to know someone already in that group (i.e. Galvin, 1983; Krebs, 2002; ARTIS International, 2009; Hamid, 2017; Schuurman, 2017). While these analyses can tell us which individuals know each other, they do not explain *how* they know each other. There is a need for a better understanding of interactions within spaces, but there are very few studies that examine the spatial element of these networks. Certainly, there are several process variables including setting events, personal factors, and the social, political and organisational context which need to be considered and should not be overlooked. However, risk factors for involvement in terrorism cannot explain differences between two individuals with the same 'risk factors', where only one of them will be recruited into a terrorist organisation. Neglecting social network and geographical information means the risk is inaccurately estimated.

7.4 TRACK framework

At present, the most commonly used model of terrorist target selection is Clarke and Newman's 'EVIL DONE', where target attractiveness is considered by the following factors: *exposed, vital, iconic, legitimate, destructible, occupied, near*

and *easy*. Terrorist strategies are continuously changing in response to increased counter-terrorism capability. Rather than being high-level and complicated, recent attacks are demonstrating a lower level of sophistication that can go undetected. Attacks tend to be lower risk and on soft targets, meaning EVIL DONE's high level focus, and certain factors of the model such as *vital, iconic* and *destructible,* can now be considered less pertinent. The framework presented in this chapter should not be viewed as a criticism of EVIL DONE as its focus on high impact attacks by foreign based terrorists (such as 9/11) was appropriate at the time it was introduced.

Based on the empirical analyses conducted in this thesis, the following section presents five factors that may increase the attractiveness of a potential target: *tolerable, relevant, accessible, close* and/or *known*. These five elements are not a definitive list of features that can predict whether a target will be selected (preventive actions should be focused on specific types of attacks to maximise effectiveness), but are designed to give an insight into factors that generally increase a target's appeal. They may be more or less relevant in different contexts, and are intended to cover all types of terrorist related incidents, by both group and lone actors. As such, some elements of the model may be more pertinent for some types. It is proposed that the five factors identified and put forward in this framework provide a good starting point in narrowing down potential targets. The use of this framework could be an effective way of identifying areas that would benefit from increased security such as target hardening.

7.4.1 Tolerable

Low security measures, low risk of detection up to the point of attack implementation (not during or post attack).

In line with previous research, the results from this thesis suggest that there is a consideration of costs and benefits in decision making regarding target selection.

Chapter 3 found that lone-actor terrorists tended to attack soft targets rather than hard targets. Most lone actors studied chose symbolic or arbitrary targets, with iconic targets being the least likely to be chosen. This is likely due to the increased amount of security associated with these types of targets. In chapter 4, VDR attacks were more likely to be in areas with a Catholic majority. Protestant areas may not have been in the offender's cognitive awareness space and as such they would have avoided these areas due to their limited knowledge about the inhabitants and physical infrastructure. In chapter 5, police stations were found to be significant risk factors for hoaxes, but not for bombings. This indicates that terrorists may seek less ideological targets with lower perceived risk for bombings relative to bomb hoaxes, given the potential for anonymity and ease of escape that busy places provide for actual bombings. Collectively, these findings suggest a rational consideration of risks.

Further, Gill, Marchment, Corner and Bouhana, (2018) found that, no matter the length of the planning process, terrorists weigh up various risks and benefits during the planning phase. Several potential targets are kept in mind before choosing the one with the relatively fewest risks. The factors considered encompass both subjective and objective factors and, in many ways, mirror criminological findings related to criminal cost–benefit decision making. There were many depictions of how fear and nerves negatively impacted the decision-making processes in planning and carrying out an attack. These appeared to be most intense during the commission of an attack. The weighing of security features necessitates hostile reconnaissance which itself offers risk to the terrorist in terms of detection. The conscious awareness of these objective security factors often leads to doubts, irregular behaviour, and an almost paranoid state where the terrorists often over-exaggerate the degree to which they are being watched and the number of security measures. The individuals' perceptions of the effectiveness of deployed security was important in this process.

7.4.2 Relevant

Relevant to the ideology of the individual/group.

Terrorists, being utility maximising, will target areas that they perceive will offer the highest rewards. Target choices will be governed by ideology and be reflective of the greatest benefit for their cause (Drake, 1998; O'Neill, 2005). Ideology provides a framework for target selection, and attacks are often tailored to concur with the ideological framework of the group.

For urban crime, offenders will travel further if they feel the potential value of the attack is higher. This was supported for lone-actor terrorist attacks in chapter 3. Individuals travelled further for iconic targets than symbolic or arbitrary targets, and further for symbolic targets than arbitrary targets. Urban crimes against properties usually require more planning and tend to involve longer distances than crimes against individuals, which are often of an opportunistic nature. This was true too for lone-actor terrorists. Those who attacked symbolic buildings travelled much further than those who attacked symbolic persons. Lone actors were willing to travel further for targets that are more in line with their grievance. This suggests that a consideration of costs and benefits may take place in decision making regarding target selection, and that there is a trade-off between distance to the target and the representative value of the target.

In chapter 6, it was found that an area was 14 times more likely to be selected to target if it contained an army base or police station. These features may have increased the likelihood of an attack due to the availability of targets in line with their ideology in the surrounding areas, i.e. officers travelling to and from work.

The subject(s) of an attack may not always be explicitly symbolic but attacks will be designed to communicate a message. As Asal et al (2009, p:261) state "the image of civilians dying can be much more powerful than the image of an attack on soldiers or police officers, as this risk is considered to be an element of the job." For ISIS, anyone who rejects Sharia law can be considered a legitimate target. Scholars have argued that this 'us vs them' dichotomy between members

and non-members of an organization eases the process of viewing civilians as legitimate targets (Tilly, 2003). This mindset and legitimisation of civilian targets may lead to an increase in attacks against softer targets, as they are not worried or constrained by fear that the use of excessive violence will lead to condemnation (Tucker, 2001).

7.4.3 Accessible

Easily accessible building or individual, located in a part of the city or town that is easily accessible from other areas.

Terrorist actors are more likely to target areas that are easily accessible. As well as considering effort, the risk of interception before an attack will also be deliberated. It can be concluded from the results of chapters 4 and 6 that areas more connected to other parts of the city will experience more attacks than those that are not. VDR incidents were spatially clustered, and small areas that experienced incidents were more likely to be in closer proximity to major roads. The likelihood of an area being selected by PIRA to target increased if the area contained a major road.

Major roads facilitate travel around cities and are therefore more likely to be travelled on more often than other smaller streets. Thus, an individual's familiarity with the area surrounding major thoroughfares is increased (Armitage, 2007). This in turn increases both their awareness of opportunities and their awareness of entry and exit points. Ozer and Akbas (2011) suggest the reason one of the major police stations in Istanbul, Turkey, is targeted by terrorists is because this station is connected by major streets. Zhukov (2012) demonstrated the importance of road networks in a study of insurgent activity in North Caucasus and concluded that they were the most important determining factor for the location of attacks. Similar research into urban crimes such as burglaries suggests that the risk is higher in places that are more connected to others (Armitage, 2007; Johnson & Bowers, 2010).

7.4.4   Close and/or Known

Close to the home location or other activity nodes of the offender, and/or known to the individual through their awareness space or hostile reconnaissance.

One of the most fundamental relationships in environmental criminology is that of spatial interaction and distance (Lundrigan and Czarnomski, 2006), and the findings from this thesis suggest that is also true for terrorist target selection. Offenders are more likely to attack within their awareness space, including the area close to their home and other activity nodes such as place of work/education, previous addresses and places of recreational activity.

For the lone actors studied in chapter 3, attacks in Europe followed a clear distance decay pattern. A high concentration of attacks occurred around the actor's home in Europe, with more than half (56%) of all the attacks occurring within 2 miles of the home location. The mean trip length for iconic targets was much longer than for symbolic or arbitrary targets. Those attacking arbitrary targets travelled the shortest distance of the three target types studied. These differences were statistically significant. It is likely that the attacks on arbitrary targets were more spontaneous and involved less planning than the other attacks and therefore occurred closer to home. Also, as the targets were not symbolic, it could be that the actor saw anyone as a legitimate target, which supports the theory that an individual will only travel further when no appropriate targets are available close by.

The distance decay pattern of Islamist and right wing extremists was similar to that of urban criminals and group terrorists. Single issue terrorists travelled further. This may be because they have a limited choice set of relevant targets to select from when compared to other ideologies. They therefore may be more likely to travel beyond their awareness spaces into unfamiliar areas further afield. For example, anti-abortionists in the U.S. may be forced to travel to different states due to the varying legality of abortions in different states. Ideology can therefore be considered a limiting factor in target selection. Previous research concluded that lone actors are not geographically constrained and willing to travel

long distances to commit their attack. However, the findings of chapter 3 suggest that this was due to the homogenous approach of previous studies. The findings of these studies are likely to be skewed by a small number of lone actors with single issue grievances who may have also attacked iconic targets. When these cases are removed and symbolic targets are considered, it is proposed that lone actors will travel further when it is necessary for them to do so, when the availability of relevant targets is limited.

The results of the RTM in chapter 5 identified that previous known VDR activity in the area increased the likelihood that the area would be targeted. The results indicated that they were more likely to occur in areas where other VDR activity, such as punishment attacks, protests and riots had previously occurred. This suggests that individuals are more likely to attack in places they know. An individual with the potential to commit an attack is likely to identify opportunities within their awareness space during their daily routines (Brantingham and Brantingham, 1981). One factor of this decision-making process that is yet to be determined and warrants further research is whether the selection of the final object of attack happens before or after they have decided to attack a particular *type* of target*.*

Distance was highlighted as a significant deciding factor in which areas to offend in, *ceteris paribus*, for members of PIRA. Chapter 6's method enabled distance to be used as an explanatory, rather than a dependent, variable alongside other decision criteria to analyse PIRA's target selection. A one kilometre increase in distance decreased the likelihood an area would be attacked by a factor of 0.61. The results support previous research that terrorist actors are more likely to attack within their awareness space.

7.4.5   Illustrative Examples

This section provides an analysis of terrorist incidents in the UK between January 2013 and June 2018, to see if the factors put forward in the TRACK framework

were reflected in attacks. This starting point was chosen due to a notable increase of frequency and lethality in attacks in the UK.

Inclusion Criteria

The attacks included in this assessment had to result in injuries or fatalities in the UK between January 2013 and June 2018. For an attack to be considered *tolerable* there were low situational security measures present at the target, as well as a low risk of detection or apprehension before attack implementation. To be *relevant* the target was considered to be symbolic of the ideology of the individual, designed to send a message. *Accessible* referred to the targeted building or individual being in an easily accessible area of the city, i.e. adjacent to major roads. To be considered as *close* the target was within 10 miles of the perpetrator's home address, based on chapter 3's median split of data. In the case of more than one attacker, the mean distance was used. Evidence of previous history of the perpetrator(s) at attack location i.e. place of work, education, previous address, etc., or evidence of hostile reconnaissance was used to determine whether the target could be considered as *known.*

Table 7.1. Illustrative examples according to TRACK framework

Perpetrator(s)	Date	Target(s)	T	R	A	C	K
Michael Adebolajo, Michael Adebowale	22nd May, 2013	Fusilier Lee Rigby	Y	Y	Y	Y	Y
Thomas Mair	16th June, 2016	MP Jo Cox	Y	Y	Y	Y	Y
Khalid Masood	22nd March, 2017	Westminster Bridge	Y	Y	Y	N	Y
Salman Abedi	22nd May, 2017	Manchester Arena	Y	Y	Y	Y	Y
Khuram Butt, Rachide Redouane, Youssef Zaghba	03rd June, 2017	London Bridge	Y	Y	Y	Y	Y
Darren Osborne	19th June, 2017	Finsbury Park Mosque	Y	Y	Y	N	N

Michael Adebolajo and Michael Adebowale

Tolerable: It can be inferred that Adebolajo and Adebowale did not directly attack within the barracks as they knew they would be unable to get on site due to the high security in place. However, the surrounding areas of the barracks would have offered several potential targets, i.e. soldiers travelling to and from the base.

Relevant: Rigby was returning to the Royal Artillery barracks after working at a recruitment fair for the 'Help for Heroes' charity, when he was spotted by Adebolajo and Adebowale. 'Help for Heroes' is a well-known U.K. charity that provides support for armed forces veterans and their families. As he crossed Wellington Street, the road adjacent to the barracks, they noticed his military backpack and 'Help for Heroes' sweatshirt. Adebolajo and Adebowale told witnesses of the attack that they had selected a member of the British armed forces to avenge the killing of Muslims. He proclaimed, "We must fight them as they fight us. An eye for an eye, a tooth for a tooth", and "The only reason we have killed this man today is because Muslims are dying daily by British soldiers. And this British soldier is one...". Adebolajo told detectives they were determined to murder a soldier because they were "the most fair target", and that they attacked Rigby because "it just so happened that he was the soldier that was spotted first".

Accessible: The barracks are immediately adjacent to a major road (A205). Rigby was returning to Woolwich barracks after working at the Tower when he was spotted by his killers in Wellington Street at around 2.20pm. CCTV shows Adebolajo and Adebowale driving around the barracks searching for a target for around an hour before the attack on Rigby.

Close/Known: Adeboljo and Adebowale were both born in London: the former in Lambeth, and the latter in Greenwich. Adeboljo attended the University of Greenwich. Greenwich is approximately 3 miles from The Royal Artillery Barracks where Rigby was murdered. One report places Adebolajo as a regular volunteer at an extremist stall outside a bank in Woolwich High Street, where he would distribute Islamist propaganda. Woolwich High Street is less than 1 mile from the

barracks. Another witness states that Adebolajo had been seen outside a nearby community centre encouraging people to fight in Syria, which is around half a mile from the barracks.

Thomas Mair

Tolerable: Mair chose to attack Cox outside his local library where he knew she was due to hold a constituency surgery. He carried a firearm and bladed weapon on his person which may have increased fear of detection, but as he travelled a very short distance to commit his attack (around 1 mile) it was unlikely that he would have been disrupted. The attack occurred while Cox was on her way to the surgery.

Relevant: Mair had links to far-right extremism, including the National Front and English Defence League. He believed individuals who were liberal and left-wing to be the 'cause of the world's problems'. A witness stated that Mair shouted "This is for Britain. Britain will always come first". He targeted Cox as he believed her to be a "passionate defender" to the European Union and a "traitor" to white people.

Accessible: The library is on the main road that runs through the centre of the town and connects it to the next town.

Close/Known: Mair lived 1 mile away from the library where he attacked Cox.

Khalid Masood

Tolerable: Masood used a sport utility vehicle to drive into pedestrians on the pavement of Westminster Bridge in London, before driving into the perimeter fence of the Palace of Westminster. He was shot by an armed officer and died at the scene. It can be inferred that he did not attempt to directly attack individuals

inside the Palace of Westminster, or the building itself, due to the visible security including multiple armed officers. There were no restrictions in place for the hire or purchase of this type of vehicle, so the risk of detection through suspicious purchases or behaviour was low.

Relevant: The Palace of Westminster is the meeting place of the houses of the Parliament of the U.K.: the House of Commons and the House of Lords. In the last 'WhatsApp' message sent before he committed the attack, Masood reportedly stated that he was waging jihad in revenge for Western military action in Muslim countries of the Middle East. He had also written a document named "Jihad in the Quran and Sunnah", which was sent to numerous contacts a few minutes before the attack. His photograph was on the front page and it contained multiple extracts from the Quran that could be seen as supportive of jihad and martyrdom. The attack occurred exactly 1 year after the bombings at Brussels airport and Maalbeek metro station in Belgium (22nd March, 2016), which were claimed by ISIS.

Accessible: Westminster bridge is one of the relatively few public roads connecting the north and south of the River Thames.

Close/Known: Three days before the attack, on 19th March, Masood conducted reconnaissance of Westminster Bridge in person as well as online. At the time of the attack Masood was based in Birmingham. He had previously lived in Eastbourne, Crawley and Luton (around 30 miles from the bridge).

Salman Abedi

Tolerable: Abedi attacked in the foyer of the arena once the concert had finished. At this point the bag checks were no longer being conducted so there was a low likelihood that the bomb would be detected before detonation. Old Trafford, the home stadium of the premier league football club Manchester United, is around the same distance as the arena from Abedi's home address. However, Abedi

decided against Old Trafford due to situational security measures such as metal detectors.

Relevant: Abedi had links to ISIS and regularly attended a mosque in Manchester that has links to the Muslim Brotherhood. The date of the attack was the four-year anniversary of Lee Rigby's murder.

Accessible: The arena is adjacent to the Manchester ring road that encircles the city centre.

Close/Known: Abedi was born in Manchester in 1994 and lived 4 miles away from the arena.

Khuram Butt, Rachide Redouane and Youssef Zaghba

Tolerable: MI5 report that Butt was aware of operational security and took measures to avoid detection prior to the attack. As this was a run-over attack there was little chance that the van would be intercepted and searched before the attack. There were also no restrictions in place for the hire of the vehicle.

Relevant: Butt's wife's cousin, Fahad Khan, said Butt openly expressed extremist views at family gatherings. He stated that Butt watched propaganda videos made by ISIS, and wanted to travel to Syria.

Accessible: Like that of Masood's attack, London bridge is a public road connecting the north and south of the River Thames.

Close/Known: Redouane lived in a Bedsit in Barking, London. It is believed that the trio made preparations for the attack in this location. Butt lived nearby, also in Barking. The area of Barking is 8.5 miles from London Bridge. Zaghba lived in Ilford, east London which is around the same distance away. One eyewitness reports that they saw Butt conducting reconnaissance of the London Bridge area, Trafalgar Square and Oxford Street in the days leading up to the attack. On the

night of the attack, the attackers conducted a 'dry run', driving over London Bridge 9 minutes before they commenced their attack. Two years before the London attacks Butt and Redouane are thought to have carried out reconnaissance of several prominent locations for a possible attack in Ireland.

Darren Osborne

Tolerable: There were no security measures in place at the mosque or the surrounding areas. Like the other vehicular attacks, there were no restrictions in place for the hire of the vehicle. Staff at the company in Wales where Osborne rented the van said there appeared to be nothing unusual about the transaction and that Osborne was "polite and well-mannered".

Relevant: The attack occurred during Ramadan, the ninth month of the Islamic calendar, in which Muslims fast (Sawm) to commemorate the first revelation of the Quran to Muhammad according to Islamic belief. Osborne had accessed far right anti-Muslim material in the weeks leading up to the attack. He had also received at least two messages from Tommy Robinson (real name Stephen Yaxley Lennon), the far-right former English Defence League leader. Scotland Yard's counter terrorism command stated that online material from Robinson played a "significant role" in Osborne's radicalisation. Osborne was overheard telling drinkers at a pub in Cardiff that he was a "soldier", claiming "all Muslims are terrorists", and he would "kill Muslims", the night before the attack. A handwritten note was found in the cab of the van after the attack. The note detailed complaints about terrorists on the streets and the Rotherham grooming scandal, and branded Labour leader Jeremy Corbyn a "terrorist sympathiser".

Accessible: In court, Osborne stated that road blocks had "thwarted" plans to attack the pro-Palestinian Al-Quds Day march in Mayfair, which was his intended target. This led to the attack on the mosque in North London later in the day. Finsbury Park Mosque is adjacent to an A-road.

Close: Osborne's home was around 150 miles away from the mosque. He stated that he had initially hoped to "plough through" as many people as possible at the Al-Quds Day march and hoped it would be attended by Jeremy Corbyn, the leader of the Labour party. It could be that Osborne travelled so far due to the increased amount of potential value the march offered.

Known: There is no evidence to suggest that the target area was known to Osborne.[31]

7.6 Implications

This thesis has demonstrated that paradigms from environmental criminology are useful in the study of terrorism and determined that target selection is the confluence of multiple factors that should be considered when assessing risk. The target selection framework proposed in the preceding section of this chapter provides a good starting point for more in-depth frameworks tailored to specific attack types. Most attacks studied in the illustrative examples demonstrated all elements of the framework, and all of them displayed the first three of the five factors: *tolerable, relevant* and *accessible*. This indicates that the first two SCP techniques, *increase the effort* and *increase the risks*, could be particularly pertinent for the prevention of terrorist incidents.

The opportunity to commit an attack depends on finding a suitable target that is insufficiently guarded. Softer targets, for example areas where people are likely to congregate, should be target hardened to increase the effort required to execute an attack. Security measures such as barriers, gates and the increased

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[31] However, Finsbury Park mosque is a well-known mosque in the UK. It gained notoriety under the leadership of radical preacher Abu Hamza al-Masri, who became its imam in 1997. The mosque became a 'hotbed' for radical Islamists and al-Qaeda operatives such as Richard Reid, Djamel Beghal, Mohammed Siddique Khan and Zacarias Moussaoui. In 2003 the mosque was temporarily closed after the arrest of seven men under the Terrorism Act 2000, removing Abu Hamza and his followers. The mosque reopened in 2004, and since then has not been associated with radical views.

presence of police officers may be effective tools in achieving this. There are several measures that can be implemented in a subtle fashion. Anti-ramming landscape features are now prevalent in the architectural design of London and other major cities. Reinforced concrete planters, bollards, and/or benches that can withstand vehicle-borne impact are placed in-between roads and important buildings, acting as a 'standoff' buffer zone. At London's Whitehall (the centre for the U.K. government), steel sandwich bollards are used. Also in London, the Emirates Stadium (home to Arsenal football club) has several SCP measures in place. Large concrete letters spelling out the word 'Arsenal' at the stadium's main entrance act as a barrier to vehicles. There are also concrete benches on the forecourt, designed to prevent a vehicle from weaving across, and giant ornate cannons form an obstacle for vehicles driving towards the stadium building.

Access to populous areas could be controlled through checkpoints to increase the risk of interdiction. Levels of guardianship indicate an increased amount of risk, alluding to risk of apprehension and increasing fear in the offender. This conscious awareness of these objective security factors often leads to doubts and irregular behaviour that can be detected. It should also be considered that attacks will not always be in densely populated areas with the aim of causing mass casualties, which highlights the importance of protecting buildings and individuals that could be considered as symbolic, through increased physical security and surveillance.

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