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Lone Wolf Terrorism

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Abstract

The purpose of this paper is to investigate the insights that might be generated into the nature of 'lone wolf terrorism' through the application of economic analysis. Orthodox approaches, particularly (standard) expected utility analysis and game theoretical analysis, are discussed. These tools prove useful in developing preliminary or 'first order' insights. The lone wolf terrorist exhibits a number of idiosyncrasies that present challenges to both economic analysis and government security policy. An alternative analytical framework is constructed wherein a terroristic agent makes choices on the basis of a preference ordering constructed over two moments of the distribution (measured in terms of fatalities generated by terrorist attacks). Seven predictions are yielded from the mean-variance theoretical framework and numerical estimates are computed as preliminary steps towards the full exploration of the implications of the framework. Most importantly, depending on their level of risk aversion (or risk seeking behaviour), lone wolves are expected to predominantly choose assassination, armed attack, bombing, hostage taking or unconventional attacks. Furthermore, within a range of between one and two standard deviations from the mean, it is possible that the quadratic utility function will reach a maximum. Following attacks of a certain magnitude (in terms of fatalities), it might be expected that the lone wolf will withdraw from activity for a period of time. This analytical approach may assist governments and security agencies facing the threat of lone wolf terrorism.

KEYWORDS: lone wolf terrorism, economic analysis, expected utility, game theory, security, mean-variance, assassination, armed attack, bombing, hostage taking

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Introduction

> …I am particularly concerned about loosely affiliated terrorists and lone offenders, which are inherently difficult to interdict given the anonymity of individuals that maintain limited or no links to established terrorist groups but act out of sympathy with a larger cause. We should not forget the Oklahoma City bombing in 1995, for example, which was carried out by individuals unaffiliated with a larger group — Robert S. Mueller III, Director, FBI[1]

Theodore Kaczynski was the Unabomber. He was also a 'lone wolf terrorist' who acted alone and outside of a formal organisational or command structure. He killed three people and injured a further twenty-three. By contrast, the Weather Underground were responsible for one fatality, the Grey Wolves were responsible for one fatality and four injuries, the Symbionese Liberation Army were responsible for two fatalities and the Revolutionary Vanguard were responsible for eleven injuries[2]. True lone wolf terrorists are individuals who, like Theodore Kaczynski, operate alone, without accomplices and outside of a formal terrorist organisational or command structure. This is contrasted with 'organised' terrorism committed by individuals operating with the assistance and cooperation of others and within an organisational or command structure. The two types of terrorism are distinct. An analysis of lone wolf terrorism is important because, as the examples show, a lone wolf terrorist may be more deadly than a terrorist organisation.

The solitary nature of lone wolf terrorism is its most pernicious aspect and also the most important aspect to incorporate into a formal economic analysis of lone wolf terrorism. Traditional approaches to the economic analysis of terrorist behaviour have tended to concentrate on the 'terrorist organisation' as the unit of analysis. This makes sense. Although terrorism may be perpetrated by formally or informally affiliated groups and individuals, the terrorist organisation has been the typical originator of terroristic operations. It is, for example, to terrorist organisations and not affiliated individuals that fatalities and injuries are attributed within the GTD. The economic analysis of lone wolf terrorism therefore involves a refocussing of the analytical framework to encompass the terroristic behaviour of the lone individual with no formal ties to an organisation and, for

[1] Mueller (2003).
[2] Data sourced from the Global Terrorism Database (GTD).

true lone wolves, no accomplices[3]. The starting point is that lone wolves respond to incentives[4]. Payoffs and risks are weighed up and considered carefully in the choice of attack type and target. Innovations in the payoff-risk structure generate innovations in the behaviour of the lone wolf. The absence of an economic theoretical framework within which this particular aspect of lone wolf behaviour can be analysed is an important deficiency within modern defence economics.

When applied to terroristic organisations, the two main approaches of economic analysis of terrorism—expected utility theoretical and game theoretical approaches—have proven capable of generating important results. It is to be expected that, within a certain degree of approximation, the application of these orthodox models to lone wolf terrorism will generate some useful insights. There are, however, many challenges. Do game theoretical negotiation models make sense in the context of lone wolf terrorism? How is the lone wolf suicide terrorist to be encompassed within the analytical framework? What 'scale' of attack is likely to characterise the lone wolf terrorist? Does the manner in which the lone wolf allocates resources to different attack types differ from the terroristic organisation? Is public support for the cause of the lone wolf an important consideration? The lone wolf operates at the boundary of conventional economic analysis of terrorism. It is almost certainly the case that orthodox economic models of terrorism must be augmented to ensnare the lone wolf terrorist within an economic-analytical framework. In this paper, the orthodox model is applied and some possible innovations to the orthodox approach are suggested and worked out.

This paper is organised as follows. In Section *II*, a brief review of the relevant literature is presented. This sets the scene for the application of economic models to the analysis of lone wolf terrorism. In Section *III*, the possibility of obtaining useful insights into lone wolf terrorism through the application of expected utility theory and game theoretical analysis is explored. In Section *IV*, an economic-analytical framework that augments the orthodox or traditional approach to the economic analysis of terrorism is developed and seven predictions for lone wolf terrorism are derived. In Section *V*, a preliminary statistical analysis of the payoff-risk structure of individual attack methods is undertaken and some numerical content is provided for the predictions yielded in the previous section. Section *VI* concludes the paper.

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[3] See Instituut voor Veiligheids en Crisismanagement (2007) and Spaaij (2010). A lone wolf, by definition, cannot be part of a group.
[4] See Ehrlich (1973, p.522).

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The Economic Analysis of Terrorism

Terrorism is, “the premeditated threatened or actual use of force or violence to attain a political goal through fear, coercion or intimidation” (Russell, Banker and Miller 1979, p.4)[5]. If the definition is augmented by highlighting the fact that the targets of the violence are “not directly involved with the policy making that the terrorists seek to influence” (Enders and Sandler 2002, pp.145-146), the definition may be said to contain all of the elements that are normally present in a definition of terrorism: (1) non-combatants are the targets of terrorist aggression; and (2) the terrorist action is expected to affect policy making indirectly by affecting the target audience of non-combatants (Victoroff 2005, p.4). A lone wolf terrorist engages in operations that are consistent with the definition of terrorism but does so outside of a formal command or organising structure. The lone wolf may or may not sympathise with a particular terroristic organisation and may not be motivated by a completely unique ideology or objective[6]. This is something quite different to the phenomenon that is sometimes referred to as ‘self-starter’ or autonomous cells, which operate without affiliation with an established terrorist network but may have an ideological affinity with the network (Kirby 2007). These are, however, groups of individuals and not lone wolves.

Rational actor models are applied by defence economists to the analysis of terroristic behaviour. Once an individual or group is terroristic[7], rational actor models work from the assumption that the individual’s or group’s actions will be characterised by a rational pursuit of the relevant objective (subject to constraints). The application of rational actor models to extreme behaviour like terrorism may seem strange at first. However, terroristic behaviour is structured and strategic (Wilson 2000; Pape 2003) with politics apparently being a motivating factor for many terrorists (see della Porta 1992). Psychological and psychiatric analysis has not found robust evidence of irrationality or madness (Rasch 1979; Victoroff 2005) and the historical record of terroristic incidences is characterised by structure rather than randomness (see Mickolus (1980; 1983); Im, Cauley and Sandler (1987); Weimann and Brosius (1988); Enders, Parise and Sandler (1992); Enders and Sandler (2002) and Lee, Enders and Sandler (2009)). Although rational actor models supply just one part of the complete picture of terroristic motivation and behaviour, the application of such models to terrorism has yielded several important results: (1) the deterrence effect; (2) the substitution effect; (3) the endowment effect; and (4) the preference effect.

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[5] Cited in Sandler, Tschirhart and Cauley (1983, p.37).
[6] See Instituut voor Veiligheids en Crisismanagement (2007).
[7] The study of the causes of terroristic behaviour is multi-disciplinary. An example of an investigation of the links between terrorism and socio-economic variables is Berrebi (2007).

First, terroristic agents or organisations may be deterred from undertaking a particular type of attack by the augmentation of security measures, for example, applied to particular targets. Landes (1978) demonstrates, within a rational choice expected utility framework, the impact of increased security (metal detectors) and harsher prison sentences on incidences of U.S. hijackings in the period 1961 to 1976. Second, terroristic agents or organisations substitute other types of terroristic operations for those operations that have diminished expected utility because of enhanced security. For example, increased security at embassies decreases attacks on embassies but increases attacks outside embassy compounds (Enders and Sandler 1993; Frey and Luechinger 2003). Third, the resource endowment of terroristic organisations is an important variable and one that governments and their security agencies must target in order to reduce terrorism. Because of the deterrence and substitution effects, government security policy that focuses narrowly on particular types of terrorism may not reduce incidences of terroristic behaviour. Policies that produce a diminution in the terrorists' resources are more likely to have 'across-the-board' effects (Sandler and Lapan 1988; Enders and Sandler 2002). Fourth, the risk preferences of terroristic agents and organisations are of critical importance. For example, if the government increases its mean concession to terroristic organisations during negotiations, a risk-averse terrorist organisation will increase demands (Sandler, Tschirhart and Cauley 1983). The risk aversion of agents and organisations will likely have a significant impact on the occurrences and outcomes of terroristic incidences (see Phillips 2009; Phillips 2010; Phillips 2011). All of these results are derived from the rational choice expected utility model of terrorism.

Rational choice expected utility underlies game theoretical analysis of terrorism. Game theory[8] is especially useful for analysing the strategic interactions of terroristic organisations and governments (Sandler and Arce M. 2003; Arce M. and Sandler 2005). Several important results relevant to the negotiation process have been generated: (1) the determination of the sub-optimality of the 'never negotiate' position (Sandler, Tschirhart and Cauley (1983); Atkinson, Sandler and Tschirhart (1987); Lapan and Sandler (1988)); (2) the discovery of the role that bargaining costs play in shaping the terrorist organisation's demands, the concessions granted by the government and the duration of an incident (Atkinson, Sandler and Tschirhart (1987)); and (3) the discovery that constraints on terrorist organisations by 'host states' have an impact on the likelihood that a terrorist organisation will negotiate (Bapat 2006). In addition, game theory also generates important insights into the interactions between governments seeking to combat a terroristic enemy. For example: (1) the

[8] The game theoretical analysis of terrorism may be roughly divided into three compartments: (1) models of government-terrorist negotiation; (2) models of government-terrorist-government interaction; (3) models incorporating another party, such as the 'populace'.

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choices by governments about the level of deterrence that will be applied to terrorism might result in too much or too little deterrence (Sandler and Lapan 1988); and (2) the strength of support for terrorists' causes is critical in shaping the nature of conflict (Siqueira and Sandler 2006; Bueno de Mesquita and Dickson 2007). The rigorous derivation of results that often highlight weaknesses in 'conventional wisdom' or intuition is a main advantage of game theoretical analysis[9].

Within all of this economic analysis, the focus is predominantly upon the terroristic organisation and almost never directly upon the individual terroristic agent. This is not because the models cannot be applied to individual behaviour. Indeed, they have been constructed to be applied to the analysis of individual behaviour. It is just that certain aspects of terroristic behaviour (for example, negotiation processes) are more easily analysed when the terroristic organisation is the unit of analysis and other aspects of terroristic behaviour (for example, the suicide operations of individuals) are not easily captured within the orthodox analytical approach. The lone wolf terroristic agent inhabits the boundary of orthodox economic analysis of terrorism and it is the individualistic nature of the lone wolf that is the most pertinent characteristic. Lone wolf terrorists operate in a manner that is consistent with the definition of terrorism but engage in such behaviour without any direct links to a group or organisation. A lone wolf operates alone. The orthodox economic-analytical framework that has been applied to terrorism may be expected to generate results when applied to the lone wolf terroristic agent, especially if the utility function of the lone wolf is itself a function of an organisation with which the lone wolf sympathises. The individualistic nature of lone wolf terrorism may, however, demand more subtlety from any economic-theoretical framework that is applied to its analysis.

Orthodox Economic Analysis of Lone Wolf Terrorism

The application of a basic rational actor expected utility model to lone wolf is easy and yields immediate empirically testable results. It generates results by treating the lone wolf as a rational actor. It does not, however, penetrate very deeply into the nature of lone wolf terrorism. A lone wolf terrorist with no distinct sympathies for a particular terroristic organisation may be thought of as an individual attempting to maximise an expected utility function like the Becker (1968) or Ehrlich (1973) expected utility functions for criminal behaviour that were adapted to the analysis of hijacking by Landes (1978):

$$EU = (1 - P_a)U(Z) + P_a P_c U(Z - S) + P_a(1 - P_c)U(Z - C) \quad (1)$$

[9] Also see Bueno de Mesquita (2005), Jacobson and Kaplan (2007) and Sandler and Arce (2007).

Where P_a is the probability of apprehension, P_c is the conditional probability of conviction if apprehended, Z represents the lone wolf's payoff, S is the negative payoff of a prison sentence and C represents the costs associated with apprehension when the lone wolf is not sentenced (see Landes 1978, pp.5-6). Such a model encapsulates the deterrence effect. In assessing a target or attack type, the lone wolf weighs the probability of success against the probability of capture and conviction. Harsher sentences or enhanced security around particular targets will decrease the EU associated with such targets and deter the lone wolf.

> **Lone Wolf Terrorism Prediction 1:** The implementation of higher security and harsher penalties may be expected to deter the lone wolf from a particular target or attack type.

The weakness of a model such as the one depicted in Equation (1) is that it ultimately says very little about the lone wolf. The 'deterrence' result has value when assessing a particular target or attack type or a terroristic group but its value does not translate well to the context of the lone wolf. Prediction (1) should still be expected to hold. However, the lone wolf places a more onerous burden on security agencies and analysts. Unlike the 'stream' of hijackers analysed by Landes (1978), lone wolves who plan their operations independently may generate a series of 'point attacks' characterised by 'once-off' particular attack types on particular targets. Security agencies may impose the deterrence effect upon a lone wolf by correctly anticipating a target or attack type (or by imposing harsher punishments). The single attempted or actual strike by a single lone wolf on a single (unanticipated) target is not, unfortunately, effectively modelled with a basic model that has an emphasis on deterrence (such as Equation (1)).

A rational actor model that incorporates both the deterrence and substitution effects is more flexible. Equation (1) can be thought of as being applied to a particular target or attack type. The lone wolf then applies Equation (1) to a number of alternatives and chooses the alternative that provides the highest expected utility. The lone wolf will substitute one target or attack type for another as he re-ranks the alternatives in light of changing conditions. Adapting Equation (1) to explicitly incorporate other targets or attack types is straightforward:

$$EU = \sum_{i=1}^{N} \left[\left(1 - P_{a_i}\right) U\left(Z_i\right) + P_{a_i} P_{c_i} U\left(Z_i - S_i\right) + P_{a_i}\left(1 - P_{c_i}\right) U\left(Z_i - C_i\right) \right] \tag{2}$$

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In Equation (2), the subscript, *i*, indicates that the lone wolf's EU is the sum of utility across each terroristic (or non-terroristic) operation *i*. If the lone wolf acts as if he maximises EU, innovations in the utility structure of individual operations affect EU. The lone wolf may be deterred from a particular operation but attracted to another. The model depicted in Equation (2) is not entirely satisfactory but it does explicitly encapsulate both deterrence and substitution effects within a single time period. It is also a slightly more useful representation of the lone wolf's decision calculus. By construction, the model depicted in Equation (2) can more effectively handle the 'point attacks' that might characterise lone wolves, even if only to the extent that the lone wolf may be expected to rank possible targets or attack types, to re-rank them as circumstances change and to choose only the best ranked feasible alternative.

> **Lone Wolf Terrorism Prediction 2:** The implementation of higher security and harsher penalties may be expected to deter the lone wolf from a particular target or attack type and cause him to substitute one type of attack for another.

The weakness of the model is that its analytical power does not extend far enough into the domain of the lone wolf. Attack types or targets that are not feasible or highly ranked within a preference ordering are not undertaken. Within a single time period, the lone wolf must strike with 'point attacks' rather than combinations of attack methods and targets. The deterrence and substitution effects of prediction (2) must still be expected to hold. However, security agencies viewing the lone wolf through the analytical filter of Equation (2) are left with little advance over Equation (1) and must still anticipate the lone wolf's 'points of attack'. The problem is essentially one of non-revealed preference. A single lone wolf who does not engage in a particular operation might be revealing that such an operation has been accorded inferior ranking within his preference ordering or he might be revealing no such thing. On the contrary, the operation may be planned and ready to execute. Because of the 'point attack' nature of lone wolf terrorism, it is only after a preference has been revealed that Equation (2) becomes more useful to security agencies.

The theme of the forgoing discussion is the independent and individual nature of lone wolf terrorism generates a series of 'point attacks' which are difficult to analyse within the standard utility theoretical framework. Deterrence and substitution effects should still be expected to hold for any rational actor but the guidance for security agencies that can be extracted from the analytical framework is thin because of non-revealed preferences. This stands in contradistinction to a terroristic organisation that might more readily (1) reveal preferences through propaganda (for example, Bin Laden's fatwa); or (2) fall into the structure of terroristic incidences revealed in the time series. The individual nature of the lone wolf also presents problems for the application of the 'endowment effect'. The resources and infrastructure of a terroristic organisation may subject to a diminution that can be expected to produce a diminution in terroristic incidences. Likewise, a diminution in the resources endowment of the lone wolf knocks particular attack types or targets out of the lone wolf's feasible set and may temporarily render all attack types and targets infeasible.

> **Lone Wolf Terrorism Prediction 3:** A diminution in the resources endowment of the lone wolf can be expected to produce a diminution in lone wolf terroristic activity.

The individual and, presumably, largely self sufficient nature of the lone wolf again presents analytical challenges. If security agencies can strike a lone wolf's resource endowment, it would seem likely that under such circumstances both the identity and location of the lone wolf is known and he may be permanently decommissioned. If not, of course, it seems unlikely that the resource endowment may be struck in any direct way. Security agencies operating with the guidance of the orthodox economic analytical framework must focus on across the board measures that make resources (for example, bomb-making equipment) more difficult to source. The analytical framework and the endowment effect do not translate easily to the individual and self sufficient context of the lone wolf.

The risk preferences of the lone wolf are of critical importance. The level of risk aversion[10] exhibited by the terrorist shapes the choice of attack type and target. Furthermore, if the lone wolf becomes involved in a negotiation or bargaining process with the government and its security agencies, the risk preferences that the lone wolf exhibits will certainly shape his actions within such a process. An increase in the risk the lone wolf associates with particular targets or attack types may produce both deterrence and substitution effects unless the increased risk is accompanied by an increase in the expected payoff.

> **Lone Wolf Terrorism Prediction 4:** An increase in the risk associated with the payoffs of a particular terroristic operation will deter the lone wolf from undertaking the operation unless there is a commensurate increase in the expected payoffs.

[10] Risk aversion rather than risk seeking behaviour is the starting point because risk seeking behaviour unrealistically implies that the terrorist will give up units of payoff to take on more risk. Risk aversion more realistically implies that the terrorist will take on any amount of risk as long as the payoff is high enough. Of course, if the terrorist does happen to be risk seeking we may say that he has negative risk aversion.

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The risk preference effect does not suffer from the same lack of transferability to the lone wolf context. This is because the lone wolf cannot escape the distribution of payoffs that characterises terroristic operations in general. The payoffs and the variability or risk of the payoffs to terroristic operations, particularly if measured in terms of human tragedy (number of fatalities) or media coverage (which is most likely a function of the level of human tragedy), are encapsulated in a probability distribution that applies to all terroristic organisations. Only innovations in attack type and target not reflected within the distribution are unrestrained by the distribution. Governments and their security agencies may therefore determine the payoffs and risks associated with particular terroristic operations, regardless of whether they are perpetrated by an individual or group. Security measures that enhance the risk (without increasing expected payoffs) associated with particular targets and attack types generate deterrence and substitution effects. However, within a payoff-risk framework the idiosyncrasies of the lone wolf do not interfere with the analytical determination of the strength of these effects. Within a payoff-risk framework, the lone wolf is constrained by the probability distribution of payoffs to terrorism. The risk preference effect is durable when the lone wolf is considered within a payoff-risk analytical framework.

Within a game theoretical structure, the interactions between governments or between security agencies of a single government, regarding deterrence measures should still hold in the context of lone wolf terrorism. A lone wolf need not operate within a domicile and might, for instance, perpetrate an attack aboard an aircraft that he has boarded outside of the jurisdiction of the target country. The deterrence and pre-emption decisions of each of two different target countries may have implications for the other country (see Arce M. and Sandler (2005, p.186)) in the context of lone wolf terrorism but this, of course, does not provide any additional insights or predictions that deeply address the idiosyncrasies of the phenomenon. Although a particular type of pre-emption or deterrence may be required for lone wolves, the interactions of governments in executing such actions seem likely to follow similar patterns to those revealed by game theoretical analysis of terrorism. It is unclear but unlikely that a lone wolf threat would be treated differently by governments than the threat of the terroristic organisation.

> **Lone Wolf Terrorism Prediction 5:** The lone wolf terrorist presents challenges similar to the terroristic group with regard to the coordination of security policy between governments.

A lone wolf might engage in negotiations with a government, particularly if the activity involves a hostage-taking situation. The strategic interactions between governments and lone wolves are likely to follow similar patterns to those identified by historical analysis and game theoretical analysis if a negotiation process emerges. In this instance, the lone wolf has almost no defining idiosyncrasies and game theoretical analysis as it has been worked out in the context of terroristic organisations may be expected to function.

> **Lone Wolf Terrorism Prediction 6:** The lone wolf terrorist has no defining idiosyncrasies within a negotiation or bargaining context.

Game theoretical analysis applies more easily to both the lone wolf and terroristic organisation than expected utility analysis. This applies to models of government-government interaction and government-terrorist interaction. Models incorporating a third party, such as 'popular support', may be more complex when explored within a lone wolf terrorism context. It seems clear that the 'popular support' modelled in game theoretical analysis of terrorism does not apply with any significant direct force within the lone wolf context. In such models, popular support for terrorism emerges from (1) economic damage caused by counter-terror operations; (2) the assessment by the population of the government's counter-terror operations; (3) the diversion of government money to counter-terrorism (Bueno de Mesquita and Dickson (2007) and Siqueira and Sandler (2006)). The lone wolf is unlikely to precipitate counter-terror operations that galvanise public support against the government in the manner envisaged within the extant game theoretical analysis. As such, no predictions for lone wolf terrorism from the existing theory can be garnered on this point.

The application of orthodox economic analysis yields several conclusions for lone wolf terrorism. The main insights that have been reached by the application of economic analysis to terrorism may usually be expected to hold in some way or another when applied to lone wolf terrorism. Governments and security agencies that face the threat of lone wolf terrorism do not do so without the benefit of an existing analytical framework. However, the individual, independent and self-sufficient nature of true lone wolf terrorists presents obstacles to the depth of insight that can be gathered by an application of orthodox methods. The realisation that even true lone wolves are constrained by the distribution of payoffs that characterises terrorism is a point of traction that might be exploited to generate deeper results that may be implemented in an operational sense by governments and security agencies. An analytical framework within which the predictions of the orthodox model hold but which, at the same time, encompasses the idiosyncrasies of the lone wolf will provide much more tangible analytical guidance to governments and security agencies.

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A Mean-Variance Framework

An analytical framework that exploits the constraint placed upon the lone wolf terrorist by the distribution of payoffs to terrorist incidences is a mean-variance preference ordering framework. Within this framework, lone wolves order their preferences for particular attack types or targets based only on two moments of the distribution: (1) the mean (expected payoff); and (2) the variance (risk) of the payoffs. Because the lone wolf cannot escape the distribution of payoffs that characterises terrorist incidences, the application of a mean-variance framework to lone wolf terrorism may provide computable results—insights into lone wolves' preference orderings—that cannot be attained by any other method. The method is a rational actor model but one that places a less onerous burden on both the agent and the economist seeking to analyse the agent's behaviour. A mean-variance preference ordering is likely to coincide approximately with any preference ordering constructed with full EU methods. If the agent is assumed to be characterised by a quadratic utility function, the agent's mean-variance preference ordering will be precisely consistent with a full EU ordering.

Although a mean-variance preference ordering may be constructed over any aspect of terroristic behaviour—media coverage, public support, financial payoffs—the most immediately obvious payoff is the level of human tragedy—fatalities and injuries. Furthermore, the level of human tragedy is the first and most important statistic reported by the press and, at the very least, is likely to represent a very plausible proxy for the more intangible 'political influence' that is usually considered to be the ultimate objective of terrorists. In many ways, the level of human tragedy determines the amount of coverage and attention an incident receives. This tends to facilitate the dissemination, although approximately, of the distribution of fatalities associated with particular attack methods and targets and recent evidence strongly supports the assumption that terrorists act to maximise the level of human tragedy. The individual arrested for the Washington D.C. Metro bombing conspiracy explicitly stated this as the objective (Finn, Hsu and Gibson 2010). The assumption that terrorists act to maximise the level of human tragedy is also in accordance with the very interesting finding that the number of victims in a particular attack is correlated with the number of victims of previous attacks, implying a 'contest in brutality' among terrorist groups (Caruso and Schneider 2010).

> **Assumption 1** The lone wolf makes a preference ordering of combinations of attack methods on the basis of two moments of the distribution of the fatalities associated with the particular attack method combinations.

The utility of the lone wolf is a function of the mean (expected) fatalities, F, and risk (the standard deviation of the possible divergence of fatalities from the mean). Formally,

$$U = f\left(\overline{F}, \sigma_F\right) \tag{3}$$

The lone wolf terrorist faces the task of constructing a preference ordering based upon the mean and variance of the fatalities associated with particular attack methods. If the lone wolf can combine attack methods, the lone wolf faces the task of constructing a preference ordering across combinations of attack methods. The expected payoff of a combination of attack methods may be stated as:

$$\overline{F} = \sum_{i=1}^{n} w_i \overline{F}_i \tag{4}$$

The risk or variance of the expected payoff of a combination of attack methods may be stated as:

$$\begin{aligned} \sigma^2 &= \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \rho_{ij} \sigma_i \sigma_j \\ &= \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n}\sum_{\substack{j=1 \\ i \neq j}}^{n} w_i w_j \rho_{ij} \sigma_i \sigma_j \end{aligned} \tag{5}$$

Where ρ_{ij} is the correlation coefficient that expresses the degree of correlation between the fatalities generated by attack method i and attack method j and w_i is the proportion of resources allocated to attack method i. It should also be noted that $\rho_{ij}\sigma_i\sigma_j$ is equal to the covariance between attack methods i and j $\left(\sigma_{ij}\right)$. The double summation sign simply implies that all possible pairs of attack methods must be accounted for.

Within this framework, the lone wolf will consider the set of attack method combinations that have the highest payoff for each level of risk. The set of attack method combinations that have the highest payoff for each level of risk is the 'efficient set'. The efficient set may be determined by repeatedly solving the relevant quadratic programming problem (Strong 2006, p.155):

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$$\min \sigma^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \rho_{ij} \sigma_i \sigma_j$$

Subject to a target $\overline{F}*$:

$$\overline{F} = \sum_{i=1}^{n} w_i \overline{F}_i = \overline{F}* \tag{6}$$

And the constraints:

$$\sum_{i=1}^{n} w_i = 1$$

$$w_i \geq 0$$

The constitution of the efficient set is important information for governments and their security agencies (see Phillips 2009). Because the lone wolf is constrained by the distribution of payoffs that characterises terroristic incidences, the lone wolf who constructs a preference ordering of attack methods on the basis of mean and variance is drawn to the efficient set of attack method combinations. Governments and their security agencies have a much narrower set of potential attack method combinations upon which to focus their attention and efforts when the lone wolf is analysed through the filter of a mean-variance preference ordering framework. A distinguishing feature of lone wolf terrorism is its lone individual nature. It would seem unlikely, at least within a single period, that a lone wolf could deploy a combination of attack methods (for example, a combination of bombing, assassination and armed assault). What is far more likely is that the lone wolf will deploy a single attack method within a period of analysis. The lone wolf is further constrained to the set of combinations within the efficient set that contain just one attack method. It is to one of these single attack method combinations that the lone wolf will devote resources in a single period. Formally,

$$\min \sigma^2 = \sigma_i^2$$

Subject to a target $\overline{F}*$:

$$\overline{F} = \sum_{i=1} w_i \overline{F}_i = \overline{F}* \tag{7}$$

And the constraint:

$$w_i \leq 1$$

A mean-variance preference ordering over attack methods does not require the assignment of a utility function. However, further insights can be obtained from doing so. The assignment of a quadratic utility function guarantees the consistency of any mean-variance preference ordering with the NM axioms. Although there has been strong debate regarding the deployment of quadratic utility functions within financial economics, a quadratic utility function will closely (locally) approximate other utility functions and closely approximate a full EU preference ordering with less computational burden and with the advantage of yielding computable results (the constituents of a rational actor's preference ordering) (see Elton *et al*. (2003, p.232); Kroll, Levy and Markowitz (1984); Levy and Markowitz (1979); Meyer (1987) and, for a discussion of theoretical considerations, especially the utilisation of mean-variance orderings for portfolio problems and the selection of the optimal choice, Baron (1977, p.1690-1692)). The assignment of a quadratic utility function provides the mechanism by which the risk preferences of the lone wolf may be analysed within the mean-variance analytical framework. Not only will such an analytical apparatus provide computable results relevant to the analysis of lone wolf terrorism that will closely approximate any full EU analysis but the special features of quadratic utility might be particularly useful for the analysis of the lone wolf.

Formally, the specific functional form of the utility function that emerges from a situation where the terroristic agent with quadratic utility makes choices solely on the basis of two moments of the distribution (mean and variance) of payoffs may be expressed formally as:

$$U(F) = c + aF - dF^2 \tag{8}$$

If the terroristic agent happens, for a given payoff, to prefer a smaller variance of payoffs to a larger variance, then $d > 0$. The application of a

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quadratic utility function has a number of distinct advantages. A quadratic utility function permits the analysis of the effect of the risk aversion parameters on the utility generated by particular payoffs. It will do so in a manner that will locally approximate other specifications of utility functions. A number of additional insights into lone wolf terrorism may be generated by the application of quadratic utility. The features of quadratic utility that are most important and relevant are listed below:

1. The quadratic utility function ensures that the equilibrium weights assigned to particular attack methods by lone wolf terrorists are not influenced by the finiteness of the mean and variance of the attack method combinations (see Ohlson 1977). Analysis may proceed, for example, even when lone wolf terrorists are assumed to face infinite risk.
2. The quadratic utility function must reach a maximum at some point. This is a problem within financial economics but not for defence economics. Beyond some point, additional expected fatalities at a constant risk level will result in a reduction in the allocation of resources to risky attack method combinations (see Wippern 1971). This diminishing marginal utility of fatalities past some point ensures that the mean-variance framework is consistent with the accepted definitions of terrorism.
3. The question of the location (within the range of payoffs) of the satiation point is an important one. It is possible that satiation occurs within a relevant (not extreme) range of payoffs to attack method combinations. In this case, whether satiation is interpreted as encompassing some political aspect of terrorism beyond merely accumulating fatalities or as something that occurs at a moment of self-destruction, large or extreme payoffs—payoffs that are many standard deviations from the mean—are not necessarily required to entice the lone wolf. Governments and their security agencies may confine their analysis to the distribution of payoffs to terrorism.

The theoretical-analytical framework that has been set down in this section yields a number of predictions for the lone wolf terrorist. The predictions that are generated from this particular analytical framework encompass those of the orthodox expected utility approach to the analysis of terrorism. However, the implications are more precise and computable results relevant to the set of attack method combinations from which the rational lone wolf will select are obtainable. The predictions that are yielded from the mean-variance analytical framework with quadraticity of the lone wolf terrorist's utility function are listed below. Each prediction is accompanied by an example or interpretation in order to add more concreteness to the predictions and provide an indication of their practical application and relevance.

> **Prediction 1** The lone wolf terrorist will be deterred from engaging in terroristic activity by an augmentation in the variance of the expected payoffs.
>
> **Interpretation** Lone wolf activity will decrease when the lone wolf perceives an increase in the variability of the fatalities that can be expected from an attack (and vice versa). For example, random screening of packages delivered to all government departments will likely increase the variability of the fatalities that the lone wolf can expect from a 'letter bombing' campaign. Publicised security alerts that heighten awareness among targets will also likely have the same effect.
>
> **Prediction 2** The lone wolf terrorist will reorder his preferences for attack method combinations on the basis of changes to the two moments of the distribution of payoffs.
>
> **Interpretation** When there is a change in either the expected fatalities and/or the variability of the expected fatalities associated with a particular attack method (or combination), the lone wolf will change his preferences for that attack method. For example, news of a bombing campaign that generates an inordinate number of fatalities may increase the expected fatalities associated with bombing and reposition the attack method at a higher position in the lone wolf's preference ranking.
>
> **Prediction 3** An increase (decrease) in the risk aversion of the lone wolf will induce a preference re-ordering. Likewise, an increase (decrease) in the risk (the second moment of the distribution) will induce a preference re-ordering.
>
> **Interpretation** The quadraticity of the lone wolf's utility function implies that the lone wolf will be observed to allocate more resources (including time) to the *less* risky attack methods (or combinations) as his recorded fatalities and injuries increase.

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Prediction 4 Lone wolf terrorists will choose attack method combinations that are contained within the efficient set of combinations (those that have the highest expected payoff for a given level of risk).

Interpretation The lone wolf will be observed to deploy (or exhibit a tendency to deploy) the attack methods (or combinations) that dominate others in terms of expected fatalities for a given level of risk. These attack method combinations are computable. This represents valuable information to the government and its security agencies.

Prediction 5 Lone wolf terrorists, at least within a single period of analysis, will choose attack method combinations that are constituted by a single attack method.

Interpretation Lone wolf terrorists, for the reasons explained above, will choose single attack methods at particular points in time. This follows logically from the nature of the lone wolf.

Prediction 6 Past some point, the lone wolf terrorist may experience decreasing marginal utility from fatalities generated by attacks.

Interpretation After some period of success, the lone wolf will be observed to reduce or cease his activity. He may resume again after some time has elapsed.

Prediction 7 The lone wolf will be found to inhabit a relevant range of the distribution of payoffs to terroristic incidences.

Interpretation The lone wolf need not be attracted to the extreme tails of the distribution or to activity that sits outside of the distribution of fatalities associated with terrorist activity in general. Lone wolves may be satisfied by very low levels of fatalities and engage in terrorist activities that place them well within the probability distribution of fatalities.

The insight that the lone wolf is subject to and constrained by the probability distribution of payoffs and risks that characterises terroristic operations and the durability of the risk preference effect is of critical importance.

It provides the opening for the construction of a theoretical framework that encompasses the individual and 'point attack' nature of lone wolf terrorism and generates insights into the payoff-risk tradeoffs that will bait the lone wolf. The predictions of the orthodox model will hold in such a framework but in a manner that provides much more tangible analytical guidance to governments and their security agencies within the context of the lone wolf. A mean-variance preference ordering approach to the analysis of terrorism enhances the traditional or orthodox approaches to the expected utility analysis of terrorism and generates computable results that may assist governments and security agencies in their pursuit of both terrorists associated with terrorist organisations and the insidious lone wolves.

Statistical Analysis and the Lone Wolf's Single Attack Method Combinations

The analysis of the lone wolf within a mean-variance framework commences with the identification of the properties of the distribution of terroristic incidences and, in particular, the payoffs and risks associated with attack methods. Using the RAND Corporation's data for terroristic incidences (the MIPT database), the average payoff and the risk associated with each of ten attack methods may be computed for the period 1968 to 2007. The ten attack method types covered by RAND are (1) armed attacks; (2) arson; (3) assassination; (4) hostage; (5) bombing; (6) hijacking; (7) kidnapping; (8) 'other'; (9) unconventional[11]; and (10) 'unknown'. Of all of these attack methods, bombing, unconventional and hostage taking incidences have the highest risk and also the highest level of expected fatalities per attack per year.

[11] The 9/11 terrorist attacks represent the most prominent recorded incidents of this class in the RAND-MIPT database. A nuclear or biological attack would be recorded as 'unconventional' were such an attack to occur.

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Table 1. Statistical Summary 1967 to 2007 of Attack Methods

Attack Method	Variance	Standard Deviation	Average Annual Fatalities Per Incident
Armed Attack	1.261	1.122	1.296
Arson	0.565	0.7519	0.322
Assassination	0.15	0.3877	1.045
Hostage	135.79	11.653	3.62
Bombing	28.311	5.32	4.604
Hijacking	14.816	3.8491	1.566
Kidnapping	0.113	0.3355	0.393
Other	3.756	1.9379	0.473
Unconventional	576.281	24.005	3.883
Unknown	16.028	4.003	0.915

The lone wolf terrorist cannot escape this distribution. Combinations of these attack methods form the choice set from which terrorists and terroristic organisations choose. From the complete choice set, lone wolves and terroristic organisations select from those attack method combinations that have the highest expected payoff for a particular level of risk. That is, from the efficient set of attack method combinations that solve the quadratic programming problem outline in the previous section. Phillips (2009) presents calculations of the efficient set using the RAND data. Attack method combinations that constitute the efficient set are characterised by their weighting schedules (resource allocations). For example, 50 percent armed assault, 10 percent kidnapping, 30 percent bombing and 10 percent assassination. Unlike a terroristic organisation, the lone wolf, at least within a single period, is more likely to be constrained at each given level of risk to the corner combinations that contain a single attack method. The determination of these ‘single attack method’ combinations is undertaken in this section.

For each of the attack methods listed above, the RAND data for a forty-year period is utilised to compute the expected payoff for individual attack methods over a range of standard deviations and the weight (percentage of resources that would be devoted to the attack method) accorded to the individual attack method at each standard deviation. For each attack method, the weight and expected payoff at levels of standard deviation ranging from 0.05 fatalities per attack per year to 11.5 fatalities per attack per year are computed. Formally, a range of values for Equation (9) were established.

$$\sigma_i = \sqrt{\frac{\sum_{i=1}^{n}\left(F_i - \overline{F}\right)^2}{n-1}} \tag{9}$$

Equation (9) is the equation for the standard deviation (risk) of a single attack method, *i*. For the range of values for Equation (9), the expected payoffs of combinations consisting of single attack method at particular weights were computed. The following quadratic programming problem, which is essentially equivalent to the problem above, was solved over the range of standard deviations for attack method combinations consisting of single attack methods ($i = 1$):

$$\max \overline{F} = w_i \overline{F}_i$$

Subject to a target standard deviation $\sigma_i *$:

$$\sigma_i * = \sqrt{\frac{\sum_{i=1}^{n}\left(F_i - \overline{F}\right)^2}{n-1}} \tag{10}$$

And the constraint:

$$w_i \leq 1$$

The results of the calculations are presented in Tables Two and Three. The range of standard deviations is contained within the first column. For each attack method, *i*, the weight (percentage of resources) and expected payoff that is consistent with each level of standard deviation is presented. For example, at a standard deviation of 0.055416418 fatalities per attack per year, five percent (0.05) of resources allocated to 'armed attack' generates an expected payoff of 0.064804 fatalities per attack per year.

Table 2. The Lone Wolf's Efficient Set of 'Single Attack Method' Combinations, Part One

	Armed Attack		Hostage		Arson		Assassination	
Standard Deviation	Weight	Payoff	Weight	Payoff	Weight	Payoff	Weight	Payoff
0.055416418	0.05	0.064804	0.004817528	0.01743797	0.074658651	0.024024957	0.144797319	0.151244
0.110832836	0.1	0.129609	0.009635231	0.03487657	0.149321343	0.048051214	0.28959725	0.302491
0.221665672	0.2	0.259217	0.019270374	0.069752825	0.298639991	0.09610156	0.579189275	0.604977
0.332498507	0.3	0.388826	…	…	0.447961334	0.144152774	0.868783912	0.907466
0.443331343	0.4	0.518434	…	…	0.59728133	0.192203554	1	1.044524
0.554164179	0.5	0.648043	…	…	0.746599978	0.240253901	…	…
0.664997015	0.6	0.777652	…	…	0.895919974	0.288304681	…	…
0.775829851	0.7	0.90726	…	…	…	…	…	…
0.886662686	0.8	1.036869	…	…	…	…	…	…
0.997495522	0.9	1.166477	…	…	…	…	…	…
1.108328358	1	1.296086	0.096352393	0.348766013	…	…	…	…
1.150287317	…	…	0.1	0.361969227	…	…	…	…
2.300574634	…	…	0.2	0.723938455	…	…	…	…
3.450861951	…	…	0.3	1.085907682	…	…	…	…
4.601149269	…	…	0.4	1.447876909	…	…	…	…
5.751436586	…	…	0.5	1.809846137	…	…	…	…
6.901723903	…	…	0.6	2.171815364	…	…	…	…
8.05201122	…	…	0.7	2.533784591	…	…	…	…
9.202298537	…	…	0.8	2.895753819	…	…	…	…
10.35258585	…	…	0.9	3.257723046	…	…	…	…
11.50287317	…	…	1	3.619692274	…	…	…	…

Table 3. The Lone Wolf's Efficient Set of 'Single Attack Method' Combinations, Part Two

	Bombing		Hijack		Kidnapping		Other		Unconventional	
Standard Deviation	Weight	Payoff	Weight	Payoff	Weight	Payoff	Weight	Payoff	Weight	Payoff
0.055416418	0.010551226	0.048577268	0.01458	0.02283	0.167320596	0.06569	0.02896	0.01370331	0.002338632	0.00908
0.110832836	0.021102452	0.097154536	0.02917	0.04567	0.334641192	0.13139	0.05793	0.02740613	0.004677305	0.01816
0.221665672	0.042204904	0.194309073	0.05834	0.09134	0.669282384	0.26279	0.11587	0.05481226	0.009354526	0.03632
0.332498507	0.063307356	0.291463609	0.08751	0.13701	1	0.39264	0.17381	0.08221864	0.014031832	0.05449
0.443331343	0.084409999	0.388619022	0.11668	0.18268	…	…	…	…	0.018709095	0.07265
0.554164179	0.105512261	0.485772681	0.14585	0.22836	…	…	…	…	0.023386316	0.09081
0.664997015	0.126614713	0.582927218	0.17502	0.27403	…	…	…	…	0.028063579	0.10898
0.775829851	0.147717165	0.680081754	0.20419	0.31970	…	…	…	…	0.032740842	0.12714
0.886662686	0.168819617	0.77723629	0.23336	0.36537	…	…	…	…	0.037418148	0.14530
0.997495522	0.189922069	0.874390826	0.26253	0.41105	…	…	…	…	0.042095369	0.16347
1.108328358	0.211024331	0.971544486	0.29170	0.45672	…	…	…	…	0.046772674	0.18163
1.150287317	0.219013652	1.008326884	0.30274	0.47401	…	…	0.6013	0.28443647	0.048543387	0.18851
2.300574634	0.438026924	2.016652016	0.60549	0.94802	…	…	1	0.47303341	0.097086689	0.37702
3.450861951	0.657040386	3.024978024	0.90824	1.42203	…	…	…	…	0.145630075	0.56553
4.601149269	0.875835029	4.032296598	1	1.56569	…	…	…	…	0.19417342	0.75404
5.751436586	1	4.603949943	…	…	…	…	…	…	0.242716764	0.94255
6.901723903	…	…	…	…	…	…	…	…	0.291260066	1.13106
8.05201122	…	…	…	…	…	…	…	…	0.339803453	1.31957
9.202298537	…	…	…	…	…	…	…	…	0.388346797	1.50808
10.35258585	…	…	…	…	…	…	…	…	0.436890142	1.69659
11.50287317	…	…	…	…	…	…	…	…	0.485433444	1.8851

Of interest to the defence economist (and governments and their security agencies) are those combinations of attack methods that constitute the efficient set. When considering the lone wolf terroristic agent, attack method combinations in a single period will contain just one attack method. The ability to diversify within a single period is unlikely to be a defining characteristic of the lone wolf. Of most interest, therefore, are those attack methods that dominate others at particular levels of risk. For example, consider the first row of Table Two. At a standard deviation of 0.055416418 fatalities per attack per year, a feasible—that is, a positive weighting of equal or less than 100 percent of resources—allocation of 0.14479 (14 percent) of resources to assassination dominates (has a higher expected payoff) armed attacks, arson and hostage taking. At each level of risk throughout the range of standard deviations of 0.05 fatalities per attack per year to 11.5 fatalities per attack per year, particular attack methods dominate others by having a higher expected payoff at the particular level of risk. The set of all such attack methods and risk levels constitutes the efficient set from which the rational lone wolf may be expected to choose.

At lower levels of risk—in the range of standard deviations of 0.05 fatalities per attack per year to 0.44 fatalities per attack per year—assassination dominates all other attack methods. At lower levels of risk, the lone wolf's efficient set must contain 'assassination'. At intermediate levels of risk—in the range of standard deviations of 0.55 fatalities per attack per year to 1.10 fatalities per attack per year—armed attack dominates all other attack methods. For less risk averse lone wolf terrorists, armed attack constitutes the efficient set at intermediate risk levels. At high levels of risk—in the range of standard deviations of 1.15 fatalities per attack per year to 5.75 fatalities per attack per year—bombing dominates all other attack methods. At very high levels of risk—in the range of standard deviations of 6.90 fatalities per attack per year to 11.50 fatalities per attack per year—hostage taking dominates all other attack methods. At extreme levels of risk—in the range of standard deviations of 11.50 fatalities per attack per year to 24.00 fatalities per attack per year—unconventional attacks dominate all other attack methods. When the overall range of risk levels that are possible with single attack methods is broken down into low, intermediate, high, very high levels and extreme it becomes very clear that the dominant attack methods within each risk level are assassination, armed attack, bombing, hostage taking and unconventional methods.

The implications of the analysis are clear and add numerical content to some of the predictions of the mean-variance framework presented in the previous section. First, the lone wolf should be found to inhabit a risk-payoff range of between 0.05 fatalities per attack per year with an expected payoff of 0.15 fatalities per attack per year (assassination) and 24.00 fatalities per attack per year with an expected payoff of 3.83 fatalities per attack per year (unconventional) (prediction 7). Second, depending on the lone wolf's risk aversion, the lone wolf should be found within a single period to be characterised by an attack method combination consisting solely of assassination, armed attack, bombing, hostage taking or unconventional methods (predictions 4 and 5). Changes to risk aversion or changes in the risk-payoff structure will invoke the deterrence and substitution effects (predictions 1, 2 and 3). Governments and their security agencies, in addition to their current practices, might find some utility in devoting resources to the dominant attack methods identified by the analysis. It is worth noting that the risk-payoff range for a reasonably risk averse lone wolf is located at a very low level. A lone wolf can be expected to inhabit the range characterised by an expected payoff of only 0.15 fatalities per attack per year (with a standard deviation of 0.05).

Although further analysis is necessary to determine the satiation points for lone wolves exhibiting quadratic utility and varying levels of risk aversion, there is reason to expect that satiation points (maxima of the utility functions) will be found at small standard deviations from the mean (see Wippern 1971) (prediction 6). If this happened to be the case for lone wolf terroristic agents, a risk averse lone wolf terroristic agent operating within the lowest range of standard deviations and devoting, for example, 100 percent of resources to assassination, might experience satiation at a level of fatalities between one and two standard deviations from the mean. In this case, satiation could occur at 1.04 fatalities per attack per year + 0.44 to 0.88 fatalities per attack per year. A less risk averse lone wolf terroristic agent operating within the high range of standard deviations and devoting, for example, 100 percent of resources to bombing, might experience satiation at a level of fatalities between one and two standard deviations from the mean. In this case, satiation could occur at 4.60 fatalities per attack per year + 5.75 to 11.5 fatalities per attack per year. These ranges, which appear quite plausible, might define ranges at which the lone wolf exhibiting a particular level of risk aversion could be expected to withdraw (following successful attacks generating fatalities within these ranges), at least temporarily, from active pursuit of terroristic activity.

This theoretical and analytical work may be examined against the historical record of lone wolf terrorist incidences. Doing so will give more concreteness to the analysis. As the starting point and basis for the analysis, the chronology of lone wolf terrorist attacks within the United States and other countries for the period 1968 to 2007 (developed by Instituut voor Veiligheids en Crisismanagement (2007)) is used. The Instituut voor Veiligheids en Crisismanagement (2007) identifies 29 lone wolf terrorists in operation during this time period in the United States and a further 38 likely examples of lone wolf terrorism in other countries. For the period 1968 to 2007, these 67 lone wolf terrorists were responsible for 97 fatalities and 337 injuries in at least 121 separate incidents. The average fatalities per attack per year are 0.0205 which is approximate with the lower bound of the theoretical prediction of 0.05 fatalities per attack per year (prediction 7). The theoretical analysis and the calculations formed on its basis do not generate results that differ markedly from the historical record of fatalities associated with lone wolf terrorist incidences.

The other principle predictions of the theoretical analysis concern the type of incidents attributed to lone wolf terrorists. Lone wolf terrorists, in accordance with predictions 4 and 5, have usually been characterised by an attack method combination (within a single period) consisting solely of assassination, armed attack, bombing, hostage taking or unconventional methods. In the United States, armed attacks (shootings) and bombings are the most prominent attack methods chosen by lone wolf terrorists and constitute almost all of the recorded incidents. This indicates an intermediate to high level of risk seeking preference among these lone wolves. Outside of the United States, more variety of attack methods has been deployed. Although armed attacks and bombings remain dominant, there were 11 hijackings, 3 hostage-takings and 3 arson attacks. This is in accordance with predictions 4 and 5 and, in addition, indicates that lone wolves operating outside of the United States have tended to be relatively less risk averse (more risk seeking). Interestingly, however, hijackings have gradually faded away in terms of frequency, which is an indication of a substitution-deterrence effect attributable to enhanced airport security.

Although it cannot be tested at a high level of rigour, it is possible to examine the prediction that satiation could occur at 1.04 fatalities per attack per year + 0.44 to 0.88 fatalities per attack per year. In general, the prediction that emerges is that satiation of the lone wolf may occur at very low levels and the lone wolf may be expected to withdraw temporarily from terrorist activity after some threshold is reached. Testing this prediction is not straightforward and we rely, for now, on a brief investigation of the specific case of Theodore Kaczynski (the Unabomber). This case is particularly well suited to analysis because Kaczynski perpetrated his attacks over a long period of time before finally being apprehended. The theoretical analysis and the calculations based upon it imply satiation and the possible temporary withdrawal from terrorist activities at a very low level of fatalities. This prediction characterises Kaczynski very well. In 1987, after nine years of perpetrating attacks, Kaczynski became inactive. At the point of his becoming inactive, his attacks had generated 0.21 fatalities and injuries per attack per year (0.017 fatalities per attack per year and 0.15 fatalities per attack). Detailed empirical analysis of the predictions generated by the theoretical approach outlined in this paper will shed more light on the choices of individual lone wolf terrorists.

Conclusions

In this paper an attempt has been made to encompass the lone wolf terroristic agent within an economic-analytical framework. In the first instance, the application of the orthodox economic approach to the analysis of terrorism was explored. For the most part, the conclusions are expected to hold but a number of easily identifiable idiosyncrasies that may characterise the lone wolf terrorist appear to weaken the strength of the conclusions that can be drawn. In light of this, a different approach was proposed. A rational actor framework wherein a terroristic agent makes choices on the basis of a preference ordering constructed over two moments of the distribution (measured in terms of fatalities generated by terrorist attacks) is consistent with the expected utility approach (approximately or exactly with quadratic utility) but has the advantage of providing computable results as well as being attended by a number of additional theoretical predictions for the behaviour of the lone wolf terroristic agent. Seven predictions were yielded from the mean-variance theoretical framework and numerical estimates were computed as preliminary steps towards the full exploration of the implications of the framework. Most importantly, depending on their level of risk aversion (or risk seeking), lone wolves are expected to choose assassination, armed attack, bombing, hostage taking or unconventional methods. Furthermore, within a range of between one and two standard deviations from the mean, it is possible that the quadratic utility function will reach a maximum. Following attacks of a certain magnitude (in terms of fatalities), it might be expected that the lone wolf will withdraw from activity for a period of time. This is something that may assist governments and security agencies facing the threat of lone wolf terrorism.

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