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The Preferred Risk habitat of AL-QA`Ida Terrorists

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Abstract

The purpose of this paper is to investigate the attack method choices of terrorists. In particular, this paper addresses the question of whether the attack method choices of terrorists are guided by a preferred risk habitat. Terroristic organisations might select attack methods as part of an overall 'program' in a manner that takes into consideration the overall level of risk that the organisation bears. Alternatively, they might select attack methods sequentially or 'one at a time' in a manner that is consistent with their risk preference but without considering the overall risk of their operations. The empirically testable hypothesis that emerges is that terroristic organisations who select attack methods sequentially in a manner consistent with their risk preference will choose attack methods that exhibit similar a similar level of volatility (risk). The results indicate a calculated, non-random consideration of the consequences of particular attack methods on the risk of its overall operations and the terrorist organisation's utility.

Keywords: Al-Qa`ida, risk, preferred habitat, attack methods, choices, volatility
JEL Classification Codes: H56, D74, D81

I. Introduction

The risk preferences of terroristic agents and organisations are of considerable importance. Economic analysis has demonstrated that risk preferences may be important in shaping terrorists' preferences for particular attack methods and shaping the outcomes of bargaining or negotiation scenarios. Within orthodox economic theory, a fundamental component of the theoretical framework is the assumption that risk attitudes or preferences are defined over aggregate wealth (and risk) levels. This is clearly reflected in the traditional Arrow-Pratt measures of risk aversion and the theoretical foundations of modern portfolio theory. Economic agents' choices involving risk are, within this framework, made according to the effect that the choice will have on aggregate long-term risk (Read *et al.* 1999). Read *et al*. (1999) call this 'broad bracketing'. This is the approach most likely to be consistent with utility maximisation. However, economic agents also make some risky choices without appearing to consider the effect that the choice will have on aggregate long-term risk. That is, each choice is made sequentially and in isolation. Read *et al*. (1999) call this 'narrow bracketing'. It is the implications of these approaches to choice under risk and uncertainty that are explored in this paper in the context of terrorism and terroristic behaviour. Of particular interest is the narrow bracketing that underlies the preferred risk habitat hypothesis.

The preferred risk habitat hypothesis has traditionally been utilised within financial economics to provide a possible explanation for the term structure of interest rates (see Elton *et al*. 2003).

According to the hypothesis, individuals make choices—in financial economics the choices involve risky assets—without paying attention to the aggregate level of risk that characterises the totality of all of their choices taken together. Rather, acting on the basis of their risk preferences (or attitudes), individuals make choices one at a time. Each choice taken in isolation will exhibit risk characteristics that are consistent with the individual's risk preferences. According to Dorn and Huberman (2010), the preferred risk habitat hypothesis shifts the focus of the analysis of individual's choices away from aggregate levels of risk (volatility) and towards the average component volatility (ACV). Empirically, individuals will 'specialise' in choices (components of the totality of choices) with particular risk (volatility) characteristics. The hypothesis generates a number of empirically testable propositions. In particular, the ACV of the choices made by an individual should be quite concentrated and new choices should exhibit similar volatility to previous choices (Dorn and Huberman 2010).

The purpose of this paper is to examine the implications of the preferred risk habitat hypothesis within the context of terrorist choices of attack method. There is much evidence to suggest that terrorist incidences are far from random events[1]. And there is a considerable body of theoretical evidence that suggests that risk preferences are important components of terrorists' choices (as too are the usual factors underlying the expected utility approach to the analysis of rational choice). The defence economics literature has generated a number of important insights into terroristic behaviour. The analysis contained within this paper contributes to this ongoing research program by determining whether terroristic agents have a preferred risk habitat as far as their choices of attack methods are concerned. The average component volatility (ACV) of the attack methods deployed by the Al-Qa`ida terrorist organisation is computed and assessed in the context of the preferred risk habitat hypothesis. The analysis generates some further insights into the choices of terrorists and, in particular, into the similarity of the risk characteristics (volatility) of those choices over time.

This paper is organised as follows. In Section II, a survey of the literature is presented. In Section III, the hypotheses are stated and the data and methodology are described. The results of the analysis are contained in Section IV. Section V concludes the paper with an assessment of implications of the analytical results.

II. The Relevant Literature

The motivation for this investigation derives from the long history of economic analysis of terroristic behaviour. In particular, economic analysis has contributed a number of insights regarding the choices and behaviour of terroristic agents under conditions of risk and uncertainty. Although these are usually confined to particular scenarios (such as hostage situations) or general levels of analysis (as in time series analysis of the aggregate of terroristic incidences), the application of rational actor models to the analysis of terrorism continues to hold much promise. A more general way of looking at the payoffs and risks of terroristic operations within a rational choice framework may shed more light on the nature of terroristic choice and, in particular, the role that considerations of risk play in shaping the terroristic organisation's behaviour. An analysis of the implications of 'narrow' and 'broad' choice bracketing under conditions of risk and uncertainty in the context of terrorism is absent from the extant literature. Such an analysis promises to generate insights into the risks that terroristic organisations bear, the way in which attack method choices might be formed and the degree of calculation and non-randomness that characterises the decisions of terroristic agents and organisations. The present paper contributes an analysis along these lines to the literature of the economic analysis of terrorism.

[1] See the time series analyses of Mickolus (1980; 1983), Im, Cauley and Sandler (1987), Weimann and Brosius (1988), Enders, Parise and Sandler (1992) and Enders and Sandler (2002).

"Terrorism is the premeditated use or threat of use of extra-normal violence or brutality by sub-national groups to obtain a political, religious or ideological objective through intimidation of a huge audience, usually not directly involved with the policy making that the terrorists seek to influence" (Enders and Sandler 2002, pp.145-146). This definition, which is one of very many that could have been presented, contains two elements that are common to most definitions: (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). Drawing on the von Neumann and Morgenstern axioms, the expected utility theoretic analysis of choice under risk and uncertainty provides a flexible yet rigorous analytical framework that has for a long time been deployed by defence economists to analyse the behaviour of terroristic agents. The literature is extensive and thorough reviews can be found in Sandler and Enders (2004), Sandler and Arce M. (2003), Arce M. and Sandler (2005) and Schneider, Brück and Meierrieks (2010a; 2010b). A review of the various approaches to the analysis of terrorist behaviour is contained in Victoroff (2005).

The direct and explicit analysis of the role of risk and risk aversion in the choices of terroristic agents and organisations has been undertaken in only a relatively small number of investigations. Implicitly, risk preference is incorporated into models based on Becker's (1968) and Ehrlich's (1973) approaches. A prominent example is the model deployed by Landes (1978):

$$EU = (1-P_a)U(Z) + P_a P_c U(Z-S) + P_a(1-P_c)U(Z-C) \tag{1}$$

Where P_a is the probability of apprehension, P_c is the conditional probability of conviction if apprehended, Z represents the terrorist's payoff, S is the negative payoff of a prison sentence and C represents the costs associated with apprehension when the terrorist is not sentenced (see Landes 1978, pp.5-6). Here the expected utility of the terrorist is a function of the payoff, Z, but the risks involved and the potential punishment that may be experienced from a failed attempt are also incorporated into the model. Landes (1978) applied this model specifically to the spate of hijackings that were recorded in the United States in the late 1960s and early 1970s. The empirical analysis undertaken by Landes (1978) supports the main predictions of the theoretical model. The increase in security (for example, the deployment of Air Marshalls and metal detectors) and the increase in penalties (the average prison sentence for offenders was around 40 years by the mid-1970s) that would be expected to decrease expected utility (and, therefore, incidences of the terrorist activity) did indeed precede and, one could conclude, lead to a precipitous decline in hijackings.

If a particular terroristic activity such as hijacking becomes too risky (because of increased security, for example), it is to be expected that terrorists will be deterred from that activity. A more sophisticated and explicit incorporation of risk and the role of terrorist risk preference into the economic analysis of terrorism were provided by Sandler, Tschirhart and Cauley (1983). Focussing on 'negotiation scenarios', Sander *et al*. (1983) demonstrate how the riskiness of a situation may affect the expected utility of the terroristic organisation. If concessions that might be generated by negotiations with the government are more risky—subject to more variance—the expected utility of the terroristic organisation and its willingness to engage in terroristic activities may be affected. The exact direction of the effect depends on, among other things, the risk preferences of the terroristic organisation. If the organisation is risk-seeking, it will give up expected concessions in order to take on more risk. If the organisation is risk-averse, it will require an augmentation to expected concessions to entice it to continue the particular terroristic activity under consideration. For some types of 'concession schedules' the effect on terroristic behaviour may be ambiguous (see Ross 2004; Phillips 2010). Risk and risk preference are critically important variables in the economic analysis of terrorism.

Sandler *et al*. (1983) demonstrate the importance of risk and risk preference to the outcomes of negotiation events such as hostage-taking situations. Sandler *et al.* (1983) state a utility function of the form:

$$U = U(L, D, \prod; C^*) \tag{2}$$

Where L is a measure of gain from a legal activity, D is the demand(s) against the government as a result of an illegal activity; $\prod$ is the probability that the demands are met and C^* is the most recent concession made by the government in response to terrorist demands (Sandler *et al.* (1983, pp.39–40)). Such models enable the analysis of terrorist negotiation or bargaining situations within a comparative statics framework. The analysis generates conclusions regarding the efficacy of government responses under a range of different conditions. For example, Sandler *et al.* (1983) determine that a 'no negotiation policy' may not be best under all conditions. This is, of course, contrary to 'conventional wisdom' which tends to recommend a 'never negotiate' policy on the assumption that concessions now will only increase incidences of terrorism in the future. Most interestingly, Sandler *et al.* (1983) also conclude that 'piecemeal policies' may, under certain circumstances, make matters worse.

A direct approach to the incorporation of risk and risk preference into the economic analysis of terrorism and one that is not constrained to the analysis of particular types of terroristic scenarios is provided by Phillips (2009). Rather than undertake a complete expected utility analysis of terrorist behaviour, the author presents a mean-variance preference ordering approach whereby terrorists construct a preference ordering over attack methods (and combinations of attack methods) based only on two moments of the distribution of payoffs (mean and variance). Whilst the approach incorporates all of the predictions of orthodox expected utility analysis, the approach generates computable results, including the set of attack method combinations that 'dominate' other combinations. Risk preferences play a critical role in the terrorists' choices. A risk-averse terroristic agent or organisation will take on risk providing that there are commensurate expected payoffs. The mean-variance approach to the analysis of terroristic behaviour places risk and risk preference at the forefront of the analysis. Within this analytical framework, risk preferences are observed to directly impact the choices of terrorists and the variance (risk) associated with the payoffs of particular attack methods directly affects the preference orderings of terroristic agents and organisations.

Phillips (2009) states an 'unspecified' utility function where utility is a function of the expected payoff and risk of a terrorist attack. Expected payoffs are measured in terms of fatalities and injuries and the risk of a terrorist attack is measured by the variance of the payoffs. Formally, utility is a function of the mean (expected) fatalities, *F*, and risk (the standard deviation of the possible divergence of fatalities from the mean):

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

The 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 terrorist can combine attack methods, the terrorist faces the task of constructing a preference ordering across combinations of attack methods. If the terrorist is assumed to have an expected utility function of the quadratic form, the preference ordering will be consistent with a full expected utility ordering and the NM axioms. The terrorist's quadratic utility function may be expressed in terms of payoffs, *Z*:

$$U(F) = c + aF - dF^2 \tag{4}$$

The measurement of expected payoffs and risks in terms of fatalities generated by attack method combinations has the advantage of providing a direct path towards computable results relevant to terrorist choices. Expected payoffs might, of course, be measured in other units like 'lines of newspaper coverage' or 'minutes of television news coverage' but it is almost certainly the case that the fatalities generated by a terrorist attack are the first thing reported and contribute significantly to the amount of attention an attack receives. The measurement of expected payoffs and risks in terms of fatalities permits the analysis of the preferred risk habitat of terroristic agents. If terroristic agents exhibit a preferred risk habitat with regards to their attack methods, the average component volatility (ACV) of terrorists' attack method choices will exhibit a concentration in terms of the variance that characterises the fatalities that those attack method choices generate.

The application of orthodox economic analysis to the analysis of terrorism has generated a number of important insights. Of most relevance to the present paper are those studies that have incorporated risk and risk preference into the analysis of terrorist behaviour. Earlier work identified a 'risk preference' effect and certainly demonstrated the importance of terrorist risk preference in classical bargaining or negotiation scenarios. Later work provided a theoretical and analytical framework with which to generate computable results based on a mean-variance preference ordering of attack method combinations. To investigate the preferred risk habitat hypothesis in the context of transnational terrorism requires a metric for risk. The variance of the payoffs series measures the risk of attack methods and attack method combinations. The more variable the payoffs series, the more likely it is that the actual payoff from a terrorist attack will be different from that which the terroristic organisation expected. Theoretical and empirical work in defence economics has shed much light on terrorist behaviour and the time series of terroristic incidences. This paper contributes a unique analysis of choices of terroristic agents and organisations by focussing on the structure of the riskiness of terrorists' choices over time.

III. Data, Methodology and Hypotheses

The risk of a terroristic operation and the risk preference of terroristic agents are variables of critical analytical and practical importance. Orthodox economic theory indicates that the forming of choices in a manner that considers the 'global consequences' of a sequence of many choices is more favourable to utility maximisation. However, economic agents often make choices in a manner that considers only the 'local consequences' of a single choice or small number of choices (Read *et al*. 1999; Kahneman and Lovallo 1993). The choices that are made can be quite different depending on whether economic agents 'broad bracket' or 'narrow bracket' their choices. In the context of financial economics, the formation of choices in a manner that considers only the local consequences of a choice leads to the hypothesis that individuals choose investments one at a time and, each time, consider the local consequences of that investment rather than its global consequences which are reflected in the effect of the investment on overall portfolio risk (Dorn and Huberman 2010). This is called the preferred risk habitat hypothesis.

Within the frameworks of the economic analysis of terrorism, a preferred risk habitat hypothesis implies that terroristic agents make choices regarding attack methods[2] sequentially and one at a time. Each time, the risk or variance of the payoffs (measured in terms of fatalities) of the attack method is considered narrowly without considering the impact of the particular attack method on the overall variance that characterises the terroristic organisation's combination of attack methods over time. Rather than considering the accumulated or aggregated number of fatalities at the end of a sequence of individual attack method deployments (terroristic incidences), the preferred risk habitat hypothesis implies that attack methods are assessed in terms of the gains and losses associated with each individual attack method choice. Thinking about terroristic behaviour in these terms raises interesting new issues. For example, do terrorists and terrorist organisations make choices of attack methods (or targets) without aggregating the series of attack method choices before a decision on a particular attack method is made? Do terrorists and terrorist organisations neglect future risky opportunities when making attack method decisions? Or, contrary to a narrow bracketing or preferred risk hypothesis, do terrorists and terrorist organisations consider the impact of a choice on the overall risk of their terroristic operation and objectives? Generating some results relevant to these questions is the objective of this paper.

The investigation of the preferred risk habitat hypothesis in the context of terrorism is attended by some empirically testable hypotheses. These have already been mentioned. As stated by Dorn and Huberman (2010), the preferred risk habitat hypothesis implies that agents select choices that are characterised by a level of risk (variance) that matches their risk attitudes and, therefore, 'specialise' in

[2] Other types of risky choice such as choice of attack targets could be examined in principle.

risk of the choices they make. There emerge two empirically testable hypotheses, which Dorn and Huberman (2010, p.158) express in terms of individual investors but which we shall express in terms of the terroristic agent or organisation:

H1. The variance that characterises the attack methods in the terrorist organisation's attack method combination are more concentrated than the variance of randomly selected attack methods in a similarly weighted attack method combination.

H2. When the terrorist organisation selects an attack method, the newly selected attack method has a similar variance to the previously deployed attack methods.

H2a. Because the variances of the fatalities generated by some attack methods are similar whilst others are quite different, the terrorist organisation specialises in small number of attack methods.

The data that is used to test these hypotheses is readily available and may be outlined as follows:

1. The variance that characterises each of the ten attack methods identified by the RAND Corporation is computed using the data collected in RAND's MIPT database for the period 1998 to 2007.
2. The attack methods deployed by the Al-Qa`ida terrorist organisation for the period from 1998 (the August 7th attack in Nairobi, Kenya) to November 6th 2007 (Ghalibiyah, Iraq) are obtained from the University of Maryland's Global Terrorism Database (GTD) is used.
3. Inputs necessary to test the hypotheses are computed using the data in (2) and (3). The calculations are described in this section.

Using the available data, the first hypothesis is tested by examining the dispersion of the average component volatility (ACV) of attack methods in Al-Qa`ida's attack method combination for the period 1998 to 2007 *vis-à-vis* the dispersion of the average ACV of a set of randomly selected attack method combinations over the same period. The average component volatility of an attack method combination is (Dorn and Huberman 2010, p.160):

$$ACV = \sum_{i=1}^{N} w_i \sigma_i \tag{5}$$

Where w_i is the proportion of attack method i in Al-Qa`ida's attack method combination and σ_i is the standard deviation of attack method i. A measurement of the dispersion of ACV for a given period is (Dorn and Huberman 2010, p.161):

$$D = \sum_{i=1}^{N} w_i \left(\sigma_i - ACV\right)^2 \tag{6}$$

Given the proportions of each attack method i in Al-Qa`ida's attack method combination and the standard deviations of those attack methods, attack methods are chosen at random to replace attack methods in Al-Qa`ida's attack method combination (see Dorn and Huberman 2010, p.161). For example, if armed attacks constitutes 10 percent of Al-Qa`ida's attack method combination, a randomly selected attack method (which can include armed attacks, though only once) is selected and allocated to the random attack method combination in that proportion. Equation (6) is computed for the random attack method combination and Al-Qa`ida's attack method combination. Then the statistical significance of the difference between the dispersion that characterises Al-Qa`ida's attack method combination and the average of a set of random attack method combinations is computed to test the validity of the first hypothesis.

The second hypothesis is tested by comparing the ACV of attack methods deployed by Al-Qa`ida in period t with those deployed in period $t - 1$. If a terroristic agent or organisation exhibits behaviour consistent with the preferred risk habitat hypothesis, each new attack method chosen will exhibit similar volatility to the attack method that it replaces. Of course, instances of repeated deployment of the same attack method year after year must be excluded from the analysis of the second hypothesis (such behaviour is already captured in the analysis of the first hypothesis).

Al-Qa`ida's choices for the period under consideration will be analysed carefully in the next section. However, the organisation does appear to change its focus from time period to time period and particular attack methods come and go from the organisation's overall attack method combination. The ten attack methods are separated into three categories (low standard deviation, medium standard deviation and high standard deviation). For each year 1998 to 2007, the volatility of any new attack method added to the combination by Al-Qa`ida is compared with the volatility of the previously deployed attack method that it replaces. The prevalence of one particular category over the others constitutes evidence consistent with the second hypothesis.

The investigation of the preferred risk habitat hypothesis promises to provide new insights into the formation of choices by terroristic organisations. That risk and risk preference affect the choices and behaviour of terroristic organisations is a result documented within the defence economics literature. The analysis presented in this paper is an extension of this literature. The investigation of the first hypothesis involves comparing the concentration of Al-Qa`ida's attack method choices to the concentration that characterises randomly constructed attack method combinations. The non-rejection of the first hypothesis will imply that the terroristic organisation concentrates its resources within a 'preferred risk habitat' and makes calculated and non-random choices of attack methods. The non-rejection of the second hypothesis and its sub-hypothesis will imply that the terroristic organisation deploys resources to a narrow range of attack methods with similar risk characteristics. It will be important to identify potential evidence of a particular type of behaviour. That is, behaviour predominantly consistent with a preferred risk habitat but with demonstrated instances of calculated emergence from the preferred risk habitat to strike with attack methods of diverse risk characteristics in a manner indicative of a calculated awareness of the global consequences of particular attack methods for the terroristic organisation's utility maximisation.

IV. Al-Qa`ida's Choices of Attack Methods

The time series record of Al-Qa`ida's terroristic attacks for the period 1998 to 2007 is obtained from the Global Terrorism Database (GTD). The data provides the basis for the analysis of Al-Qa`ida's choices of attack methods. The fatalities generated by each of the terroristic organisation's attacks are presented in Table One.

Table One: Al-Qa`ida's Generated Fatalities 1998 to 2007

Attack Type	Bombing	Armed Assault	Arson	Assassination	Hostage (Kidnapping)	Unconventional	Unknown
1998	117.5 (2)	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	19 (1)	0	0	0	0	0	0
2001	0	0	0	0	0	403 (4)	0
2002	13.75 (12)	0	0	3 (1)	1 (1)	0	12 (1)
2003	7.47 (21)	1.60 (5)	0	15 (1)	0 (1)	0	0
2004	27.18 (16)	10.66 (3)	0	0	0	0	0
2005	8.50 (4)	0.50 (2)	0 (1)	2 (1)	0	0	0
2006	4.25 (4)	5 (2)	0	11 (1)	0	0	0
2007	8.55 (9)	2 (2)	0	0	0	0	0

Notes: The figures in the columns report the number of fatalities per attack for each year. For example, the GTD Database records four attacks on September 11th 2001 generating a total of 1,612 fatalities or 403 fatalities per attack. The numbers in parentheses identify the number of incidents that took place during the year. Where a 'zero' is input into a cell in the table (and there are no accompanying numbers in parentheses) there were no incidents of that particular attack type in the year. The mean is the mean number of fatalities per attack per year. Shaded areas indicate, roughly, new additions to the attack method combination.

Of most interest is (1) the overall dominance of particular attack methods; and, especially, (2) the innovations in attack methods over time (that is, the absence of some previously deployed attack methods and the inclusion of new attack methods). In most years, bombing is the dominant attack method utilised by Al-Qa`ida in the transnational terroristic operations it perpetrates. However, the

9/11 terrorist attacks involved the introduction of 'unconventional' attack methods and, in subsequent years, hostage (or kidnapping), armed assault and assassination. It appears that the bombing operations of previous years were replaced by the unconventional attacks of 2001 which were, in turn, replaced with a return to bombing in combination with kidnapping, armed assault and assassination. There was a return to bombing and armed assault in 2004 and no recorded incidences of kidnapping or assassination. Al-Qa`ida does appear to specialise in particular attack methods (bombing and armed assault). However, the organisation appears to form a broader attack method combination over time and is not averse to incorporating higher risk-higher return operations (unconventional attacks) into the overall attack method combination or, as necessary, lower risk-lower return operations (arson and assassination).

To test the first hypothesis with reference to the Al-Qa`ida terrorist organisation requires the computation of the ACV of each of the attack methods deployed by Al-Qa`ida. The components of the ACV computation are the proportions of each attack method within Al-Qa`ida's attack method combination and the standard deviations of those attack methods. The standard deviations of the attack methods are computed from the overall time series of terroristic incidences (not just those perpetrated by the Al-Qa`ida terrorist organisation). Using the RAND Corporation's data for the period 1998 to 2007, the mean and variance for each attack method is computed. The results are presented in Table Two.

Table Two: Historical Fatalities for Attack Methods 1998 to 2007 (RAND Data)

	Armed attacks	**Arson**	**Assassination**	**Hostage**	**Bombing**	**Hijacking**	**Unconventional**
Variance	2.92	0.89	0.06	527.50	4.00	1.33	2492.28
Standard Deviation	1.71	0.94	0.24	22.97	2.00	1.15	49.92
Average Annual Fatalities Per Incident	1.93	0.37	1.46	11.72	4.95	0.55	16.83

For the period under analysis, the Al-Qa`ida terrorist organisation's attack method combination consisted of: (1) bombing 72.63 percent; (2) armed assault 14.73 percent; (3) arson (incendiary) 1.05 percent; (4) assassination 4.21 percent; (5) hostage (kidnapping) 2.10 percent; (6) unconventional 4.21 percent; (7) unknown 1.05 percent. According to the Global Terrorism Database (GTD), the Al-Qa`ida organisation has not engaged in 'hijacking' or 'other' attacks, which are the two additional attack method types listed by the RAND Corporation. The ACVs for Al-Qa`ida's attack method combination are presented in Table Three.

Table Three: Al-Qa`ida's Attack Method Combination: Average Component Volatilities

Attack Method	w_i	σ_i	$w_i\sigma_i$
Bombing	0.7263	2.00	1.4526
Armed Assault	0.1473	1.71	0.251883
Arson	0.0105	0.94	0.00987
Assassination	0.0421	0.24	0.010104
Kidnapping	0.0210	22.97	0.48237
Unconventional	0.0421	49.92	2.101632
Unknown	0.0105	0.79	0.008295

The ACV for Al-Qa`ida's attack method combination is 4.3167 (measured in terms of generated fatalities). Now use equation (6) to compute a measure of the dispersion, *D*, for the ACV of Al-Qa`ida's attack method combination. The result of this computation is 100.7095. To determine whether this measure of dispersion indicates 'concentration' or 'diversification' it must be compared with the average of the dispersion measures for random attack method combinations. Ten (10) attack method combinations were formed completely randomly by assigning numbers to each attack method and using a random number generator to form an attack method combination. The composition, ACV

and dispersion measures for these 10 randomly constructed attack method combinations are reported in Table Four.

Table Four: Random Combinations: ACVs and Dispersion Measures

Combination	1	2	3	4	5	6	7	8	9	10
w_i										
0.7263	Assassination	Bombing	Bombing	Arson	Unconventional	Kidnapping	Armed Assault	Unconventional	Kidnapping	Bombing
0.1473	Unconventional	Armed Assault	Unknown	Kidnapping	Kidnapping	Unknown	Unconventional	Armed Assault	Bombing	Armed Assault
0.0105	Unknown	Arson	Arson	Unknown	Arson	Arson	Arson	Assassination	Unconventional	Assassination
0.0421	Kidnapping	Assassination	Kidnapping	Armed Assault	Assassination	Unconventional	Unknown	Kidnapping	Arson	Kidnapping
0.0210	Armed Assault	Kidnapping	Armed Assault	Assassination	Bombing	Bombing	Assassination	Arson	Unknown	Arson
0.0421	Bombing	Unconventional	Unconventional	Unconventional	Unknown	Assassination	Bombing	Bombing	Armed Assault	Unconventional
0.0105	Arson	Unknown	Assassination	Bombing	Armed Assault	Armed Assault	Kidnapping	Unknown	Assassination	Unknown
ACV	**8.63**	**4.31**	**4.68**	**6.49**	**39.75**	**18.98**	**8.96**	**37.59**	**17.63**	**4.80**
D	**315.03**	**100.7**	**108.23**	**146.75**	**307.15**	**127.99**	**294.48**	**419.44**	**99.17**	**107.4**

The average ACV of ten randomly constructed attack method combinations is 16.15 and the average dispersion, D, of the randomly constructed combinations is 202.63. Both of these numbers are well in excess of the corresponding numbers for Al-Qa`ida's attack method combination. Following Dorn and Huberman (2010, p.162), the square of the dispersion of an attack method combination provides information about the band in which the volatilities of the attack method combinations will probably lie. Al-Qa`ida's attack method combination, which has an ACV of 4.3167 and a dispersion of 100.7095, is an attack method combination in which the component (attack method) volatilities are likely to lie in the band of 20.07 (which is $2 \times \left(\sqrt{100.7095}\right)$) between –5.71 and 14.35. The average ACV and D of the randomly constructed attack method combinations is characterised by a band that is much larger at between 1.91 and 30.38. The band is 40 percent wider for the randomly constructed attack method combinations. This is consistent with H1. If Al-Qa`ida selected its attack methods at random, the concentration of ACV observed to characterise Al-Qa`ida's combination of attack methods would not be expected.

Table Five: Random Combinations: ACVs and Dispersion Measures (Second Group)

Combination	1	2	3	4	5	6	7	8	9	10
w_i										
0.7263	Unconventional	Unconventional	Unconventional	Unknown	Bombing	Arson	Unknown	Unconventional	Assassination	Kidnapping
0.1473	Kidnapping	Armed Assault	Unknown	Bombing	Kidnapping	Kidnapping	Assassination	Assassination	Arson	Unconventional
0.0105	Armed Assault	Unknown	Kidnapping	Arson	Assassination	Unknown	Armed Assault	Unknown	Bombing	Assassination
0.0421	Arson	Bombing	Assassination	Unconventional	Unconventional	Unconventional	Kidnapping	Armed Assault	Kidnapping	Unknown
0.0210	Assassination	Kidnapping	Bombing	Armed Assault	Armed Assault	Assassination	Bombing	Kidnapping	Unknown	Armed Assault
0.0421	Unknown	Arson	Armed Assault	Kidnapping	Arson	Bombing	Unconventional	Bombing	Unconventional	Arson
0.0105	Bombing	Assassination	Arson	Assassination	Unknown	Armed Assault	Arson	Arson	Armed Assault	Bombing
ACV	**39.75**	**37.12**	**36.74**	**3.98**	**7.02**	**6.28**	**3.74**	**36.94**	**3.43**	**24.16**
D	**306.84**	**443.07**	**465.07**	**112.35**	**136.29**	**143.99**	**113.66**	**455.84**	**115.56**	**166.21**

In order to provide additional rigour, a second group of ten randomly constructed attack method combinations was selected. The details are reported in Table Five. Notice that the first set of random combinations contained in Table Four includes, by chance, a combination that mirrors Al-Qa`ida's combination. Even with this similarity embedded in the analysis, the average dispersion of the random combinations reported in Table Four is much higher than Al-Qa`ida's combination. For the combinations reported in Table Five, the average ACV is 21.69 and the average D is 223.53. This

generates a volatility band of between 6.74 and 36.64, which is 48 percent larger than that which characterises Al-Qa`ida's attack method combination. This is consistent with H1.

To test the second hypothesis, the attack methods are placed in three categories: (1) high risk; (2) medium risk; and (3) lower risk. The categorisation is fairly straightforward. It is really just a grouping of attack methods on the basis of similarity of risk levels (standard deviations in Table Two). The categorisation is presented in Table Six.

Table Six: Categorisation of Attack Methods

Attack Method	Lower Risk Standard Deviation = 0.00 to 1.00	Medium Risk Standard Deviation = 1.00 to 2.00	High Risk Standard Deviation + 2.00
Bombing		x	
Armed Assault		x	
Arson	x		
Assassination	x		
Kidnapping			x
Unconventional			x
Unknown	x		

H2 is addressed by determining whether Al-Qa`ida replaces previously deployed attack methods with new attack methods that exhibit similar risk characteristics. To make this determination, for each year 1998 to 2007, whenever Al-Qa`ida replaced one attack method with another, it was determined whether the previously deployed attack methods and newly deployed attack methods occupy the same risk category. The series of deployments is may be listed as follows: (1) in 2000/2001 unconventional for bombing; (2) in 2001/2002 bombing, kidnapping and assassination for unconventional; (3) 2003/2004 armed assault for kidnapping and assassination. It is easy to see that this does not constitute evidence consistent with H2. Rather, a re-inspection of Table One reveals a 'branching out' or diversification into attack methods with different volatilities (risk) and then a subsequent retraction to bombing and armed assault. This is illustrated in Figure One.

Figure One: Preferred Habitat with Emergence

Attack Type	Bombing	Armed Assault	Arson	Assassination	Hostage (Kidnapping)	Unconventional	Unknown
1998	117.5 (2)	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	19 (1)	0	0	0	0	0	0
2001	0	0	0	0	0	403 (4)	0
2002	13.75 (12)	0	0	3 (1)	1 (1)	0	12 (1)
2003	7.47 (21)	1.60 (5)	0	15 (1)	0 (1)	0	0
2004	27.18 (16)	10.66 (3)	0	0	0	0	0
2005	8.50 (4)	0.50 (2)	0 (1)	2 (1)	0	0	0
2006	4.25 (4)	5 (2)	0	11 (1)	0	0	0
2007	8.55 (9)	2 (2)	0	0	0	0	0

The branching out that is evident in Al-Qa`ida's choice of attack methods is more consistent with the diversification of attack methods introduced into defence economics by Phillips (2009) than with a strict preferred risk habitat hypothesis. H2 is particularly difficult to test in the context of a terroristic organisation where diversification across attack methods appears to prevail. However, the sub-hypothesis H2a provides an additional test of the proposition derived from the preferred risk habitat hypothesis that a terroristic organisation described by the preferred habitat hypothesis will concentrate resources in a narrow range of attack methods with similar volatilities.

The Al-Qa`ida terrorist organisation does concentrate its resources to a narrow range of attack methods. In particular, the organisation focuses its resources on bombing and armed assault. These are attack methods that have very similar levels of risk. Bombing has a standard deviation of 2.00 fatalities per attack per year while armed assault has a standard deviation of 1.71. These two attack methods

constitute more than 85 percent of Al-Qa`ida's attack method combination. This is consistent with H2a. We have a very interesting situation. There appears to be evidence of ACV concentration as measured by a dispersion measurement that is very much lower than the average of a randomly constructed selection of ten attack method combinations. And Al-Qa`ida does concentrate its resources to two dominant attack methods. On the other hand, Al-Qa`ida incorporates attack methods of dramatically different volatilities in its attack method combination over time. This tends to indicate a more calculated awareness of the impact of such choices on the overall volatility of its attack method combination. Either way, the evidence implies that Al-Qa`ida's choices are very much calculated and far from random.

V. Conclusions and Implications

Phillips (2009) provided the details of an analytical framework within which to analyse the choices of terroristic organisations under risk and uncertainty. The 'portfolio or mean-variance approach' implies 'broad bracketing' of choices and the consideration of the global or overall consequences of each choice in forming an 'efficient' combination. The computational results and approach of Phillips' (2009) mean-variance framework provide the starting point for the analysis undertaken in this paper. Characterising the risk of a terroristic operation in terms of the variance or standard deviation of the payoffs generated by the deployed attack method (and measuring those payoffs in terms of generated fatalities) provides a level of 'computability' that has hitherto been absent from the application rational actor models to the analysis of terrorism. The question asked in this paper is whether a particular terroristic organisation does indeed make its choices in a manner best described as 'broad bracketing' or whether, as seems to be the case in other economic contexts, the terroristic organisation makes its choices in a manner more appropriately described by 'narrow bracketing' and the preferred risk habitat hypothesis that emerges from a consideration of narrow bracketed choices.

In short, the evidence is somewhat consistent with the preferred risk habitat hypothesis. The Al-Qa`ida terrorist organisation does appear to exhibit a more concentrated combination of attack methods than the average of a set of randomly constructed attack method combinations. And the terrorist organisation does deploy a very large percentage of its resources to only two attack methods (bombing and armed assault). However, Al-Qa`ida incorporates other attack methods into its attack method combination and these can have very divergent volatilities (especially the unconventional attacks perpetrated on 9/11). This indicates a willingness to step outside of a preferred risk habitat and a calculated awareness of the global (broad bracketed) consequences of particular attack methods. If anything, this probably makes the organisation more dangerous. However, if governments and their security agencies are aware of the choice patterns of a terroristic organisation, the government's security policies are better informed and possibly more effective. Governments should be aware that Al-Qa`ida appears to be characterised by a preferred risk habitat and, over time, concentrates its resources in a narrow range of attack methods. However, the organisation displays a calculated willingness to step outside of the preferred risk habitat in a manner that indicates an awareness of the implications on its utility of attack methods that are characterised by very divergent volatilities (risk levels).

The randomisation of terroristic operations is a matter that has attracted the attention of defence economists. This is evidenced by the relatively large number of time series analyses of terroristic incidences. Terroristic attacks are not random even though terroristic organisations might attempt to simulate randomness to confuse security agencies and enhance the terror felt by a populace. The analysis presented in this paper sheds some additional light on the non-randomness of Al-Qa`ida's attack method choices. When compared with the average dispersion of ten randomly constructed attack method combinations it became immediately clear that Al-Qa`ida's attack method combination is far more concentrated and characterised by a far narrower band of volatilities of attack methods than would be expected if Al-Qa`ida selected its attack methods at random. Together with what we have already said, a very important picture of the Al-Qa`ida terrorist organisation is emerging from the

mean-variance analytical framework that has guided the analysis presented in this paper. That is, Al-Qa`ida is a very calculating, rational organisation displaying a non-randomness of attack method selection. The organisation remains within a preferred risk habitat for the most part but can step outside of that habitat to strike with an apparently calculated awareness of the impact of particular attack methods on its utility maximisation over time.

Mean-variance analytical tools and related concepts such as ACV provide a way to extract computable numerical results in the context of terroristic choice. This contrasts with the theoretical or logical results of standard applications of expected utility and game theory. The preferred risk habitat hypothesis emerges from considering that economic agents may 'narrow bracket' their choices. In this paper, this hypothesis has been explored within the context of Al-Qa`ida's choices of attack methods. There is certainly some evidence to suggest that Al-Qa`ida does make attack method choices in a manner that is consistent with the hypothesis. The organisation's choices are characterised by a low level of dispersion and a concentration of resources in two attack methods that exhibit similar levels of risk. However, the organisation sometimes allocates resources away from its preferred risk habitat to attack methods that exhibit much higher (or lower) levels of risk. This is an unsettling finding because rather than implying incoherence, it implies that Al-Qa`ida demonstrates a calculated awareness of the consequences of attack method choice on the organisation's utility. Its choices are far from random but neither are they always consistent with a preferred risk habitat hypothesis. The organisation emerges from its preferred risk habitat to strike in a manner more reminiscent of utility maximisation and mean-variance optimisation. Determining the nature and timing of these emergences is a very important task for future research.

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