

THE LONE WOLF SUICIDE TERRORIST
A PRELIMINARY APPLICATION OF MEAN-VARIANCE METHODS

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The purpose of this paper is to investigate the insights that might be generated into the nature of 'lone wolf suicide terrorism' through the application of mean-variance analysis. Orthodox approaches to the analysis of terrorism, particularly (standard) expected utility analysis and game theoretical analysis, may need to be extended or complemented with new approaches in order to generate analytical insights into lone wolf suicide terrorism. One such approach is mean-variance analysis. Commonly deployed in financial economics, mean-variance preference orderings with quadratic utility can be applied even when the mean expected return and variance are infinite. This fact might potentially be exploited to analyse, from an economic perspective, the behaviour of the lone wolf suicide terrorist for which success might be reasonably considered to generate an infinite expected return.

Key Words: lone wolf, suicide terrorism, economic analysis, mean-variance, preference ordering, quadratic utility.

JEL Codes: H56, D74, D81

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...The Department also supports making permanent section 6001(a) of the Intelligence Reform and Terrorism Prevention Act of 2004. This provision, which has come to be known as the “lone wolf” provision, allows the government to gain court approval for FISA surveillance of a non-United States person when there is probable cause to believe that he or she is engaged in or preparing to engage in international terrorism, whether or not he or she is known to be affiliated with a larger terrorist group. While this provision is currently scheduled to sunset at the end of this year, unfortunately, the threat to the United States posed by known or apparent lone wolf terrorists will not similarly cease on December 31, 2005. Therefore, the Department strongly endorses the enactment of section 102 of the Committee’s draft legislation, which would remove the sunset on the lone wolf provision — Valerie Caproni, General Counsel, FBI²

The phenomenon that is called ‘lone wolf terrorism’ presents a challenge to defence economists and political scientists who would apply the tools of economics to its analysis. Of particular interest to the subject matter of this paper are those lone wolf terrorists who plan and perpetrate suicidal attacks. The actions of Umar Farouk Abdulmutallhab aboard North West Airlines Flight 253 in December 2009 appear to be an example of this phenomenon. Orthodox approaches to the analysis of terrorism deploy utility theoretical and game theoretical frameworks. These theoretical tools have generated a number of important insights into the behaviour of terrorists and terrorist organisations. However, the standard approach of defining an objective function which the terrorist or terrorist organisation is assumed to maximise subject to constraints and the game theoretical analysis of strategic interactions between the terrorist or terrorist organisation and the government may not apply as neatly to a situation where a lone terrorist plans and perpetrates a suicide attack outside of any formal command structure or any formal links with a terrorist organisation.

The purpose of this paper is to present a very preliminary outline of the application of mean-variance analysis to the problem of lone wolf suicide terrorism. Mean-variance preference orderings are usually deployed in financial economics to analyse investor choice. Phillips (2009; 2010) has taken the first steps towards the application of mean-variance analysis and portfolio choice to the problem of terrorism and attack method choice. Whilst quadratic utility functions have some shortcomings and Phillips (2009; 2010) did not rely upon the specification of a quadratic utility function for terroristic agents or terroristic organisations, quadratic utility will provide good approximations under most conditions and guarantee the consistency of a mean-variance preference ordering with the von Neumann-Morgenstern (NM) axioms of expected utility. For the specific problem under consideration, the application of quadratic utility to a situation where the lone wolf suicidal terroristic agent makes a choice of attack method or target on the basis of mean (expected) return and variance (risk) has the advantage of guaranteeing the consistency of the agent’s choice with the NM axioms

² Caproni (2005).

even when the expected return and risk are infinite. For the lone wolf terrorist who intends to perpetrate a terrorist action where success (and perhaps also failure) is characterised by suicide, the infinity of return and risk becomes a distinct analytical-theoretical possibility.

II. THE LITERATURE: A BRIEF SURVEY

The defence economics literature that explicitly uses the tools of financial economics to analyse matters of interest to the defence economist is very small. However, the theoretical foundation of financial economics is orthodox microeconomic theory. This is the same orthodox microeconomic theory upon which much of the analytical work of defence economics has traditionally been based. The traditional utility-optimising representative agent frameworks that are utilised to analyse topics of interest to the defence economist—including but not restricted to terrorist behaviour—are the same as those that underlie theoretical and empirical analysis of topics of interest to the financial economist—especially choice under uncertainty or risk. In addition to what may be called these ordinary ordinal utility foundations, financial economics also derives significant advantages from the deployment of von-Neumann and Morgenstern utility to the analysis of decision-making. Defence economics, mainly through the extensive utilisation of game-theoretical analysis, rests upon similar foundations. In practical application and analysis, however, tools that derive from similar theoretical roots may, through different approaches and emphasis, yield new insights.

Orthodox economic analysis of terrorism builds upon Becker's (1968) applications of expected utility theory to the problem of crime and criminal choice. In his analysis of crime, Becker (1968, pp.176) applies "...the economists' usual analysis of choice and assumes that a person commits an offense if the expected utility to him exceeds the utility he could get by using his time and other resources at other activities." Becker (1968, p.177) states a utility function of the form

$$EU_i = p_i U_i(Y_i - f_i) + (1 - p_i) U_i(Y_i) \quad (1)$$

Where Y_i is the offender's income, monetary plus psychic, from an offence; U_i is the offender's utility function; and f_i is a monetary equivalent of the punishment (if the offender is apprehended). Applied to terroristic behaviour, this type of utility analysis generates important insights. Sandler, Tschirhart and Cauley (1983) state a utility function of the form:

$$U = U(L, D, \Pi; C^*) \quad (2)$$

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; Π 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, Tschirhart and Cauley (1983, pp.39–40)). Such models enable the analysis of terrorist negotiation 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, Tschirhart and Cauley (1983) determine that a ‘no negotiation policy’ may not be best under all conditions and, most interestingly, ‘piecemeal policies’ may, under certain circumstances, make matters worse. The powerful tools of orthodox economic analysis, which are shared by financial economics and defence economics, generate important and useful results in dealing with the problem of terrorism.

Of particular interest are analyses that make explicit use of the von-Neumann and Morgenstern (NM) class of (expected) utility functions, which replace the standard ordinal utility functions of elementary economic analysis when the analysis involves situations where the choice set cannot be partitioned with certainty into attainable and unattainable sectors. Under such conditions, a pure preference ordering does not provide sufficient information for examining the choices of an economic agent. Von-Neumann and Morgenstern utility examines preference orderings over lotteries or gambles involving commodity bundles and does not directly examine preference orderings over the commodity bundles themselves. Von-Neumann and Morgenstern utility is an attractive and tractable tool with which to examine the complex structure associated with outcomes and their associated probabilities. Importantly, the von-Neumann and Morgenstern utility measurements are ordinal utilities whose differences can also be ordered. If A is better than B is better than C the NM utility index numbers assigned to A, B and C reflect this ordering but also permit statements such as, “A is better than B by more than B is better than C.” In this sense, NM utility is cardinal.

The explicit or implicit deployment of NM utility in defence economics may be undertaken as part of theoretical utility analysis (rational actor EU models) or as part of game theoretical analysis. Game theory is particularly useful in the analysis of terrorism because the strategic interactions and interdependency of choices by governments and terrorist groups are salient to the behaviour being analysed (Arce M. and Sandler 2005). The success that defence economists have had in extracting results from game theoretic analysis of terrorism is substantial (see Sandler, Tschirhart and Cauley (1983); Sandler and Arce M. (2003); Arce M. and Sandler (2005); and Sandler and Arce M. (2007)). During the consideration of scenarios where the outcomes are uncertain (such as government retaliation, deterrence and pre-emption directed at a terroristic group), expected values that emerge by weighting outcomes by their probabilities do not provide any insights into the decision-making process (unless the decision-maker is risk neutral). The deployment of NM expected utility to analyse

the utility of the decision-maker (who may display various levels of risk aversion), permits the analyst to consider the average of the utilities of the payoffs associated with a lottery or gamble (rather than the average of the payoffs). Together with the theoretical structures of game theory, (NM) expected utility analysis generates deep insights into decision-making (especially strategic decision-making) under uncertainty. For example, consider the utility analysis undertaken by Enders and Sandler (2002) where a terrorist group's expected utility is

$$E(U) = \pi U(W^S) + (1 - \pi)U(W^F) \quad (3)$$

Where $U(W)$ is the NM utility function and W^S and W^F are the net wealth equivalent measures over two states, success (S) and failure (F). In this model, the terrorist's commodity bundles are constituted by quantities of net wealth which are in turn constituted by monetary equivalents of net gains from legal and illegal activities. Such a model can be used to generate empirically testable conclusions. For example, actions by governments aimed at increasing the costs associated with a particular type of attack will reduce the relative costs of other types of attacks and produce a substitution effect. Authorities should, therefore, attempt to ensure that this substitution shifts from more harmful to less harmful attacks. Enders and Sandler (2002) note, however, that increased security at U.S. embassies has prevented a less harmful type of attack (on the embassy) but increased levels of a more harmful type of attack (on embassy personnel outside the embassy compounds). It is these types of results that have been generated by the orthodox application of expected utility theoretical and game theoretical analysis to the problem of terrorism.

Mean-variance approaches have held a place of prominence in financial economics for a long time (Markowitz (1952) and Tobin (1958)). Recent application of mean-variance analysis to the problem of terrorism generates new insights into terrorists' (optimal) choice and, when extended in a manner analogous to Sharpe (1964) and Black (1972), may also generate insights into particular equilibrium conditions (Phillips 2009; 2010). The analysis presented in this paper is an extension of the mean-variance analysis of terroristic decision-making to the problem of lone wolf suicide terrorism. A preliminary or foundational structure is developed for the application of mean-variance analysis within a context where terrorist choice is characterised at least approximately by a quadratic utility function. Within such a context, certain desirable properties of mean-variance analysis and quadratic utility functions may be exploited that might be particularly useful for the analysis of lone wolf suicide terrorism. Of special interest is the fact that quadratic utility ensures the consistency of choice with the von Neumann-Morgenstern axioms of expected utility in a situation where the mean and variance of the payoffs expected by the lone wolf terrorist are infinite.

III. LONE WOLVES, QUADRATIC UTILITY AND MEAN-VARIANCE ANALYSIS

Assume that the lone wolf suicide terroristic agent chooses among alternative targets and methods of attack so as to maximise expected utility. Utility is a function of the mean (return) and variance (risk) of the payoff, Z , the agent desires³. Formally:

$$U = f(Z_R, \sigma_R^2) \quad (4)$$

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

$$U(Z) = c + aZ - dZ^2 \quad (5)$$

If the terroristic agent happens, for a given payoff, to prefer a smaller variance of payoffs to a larger variance, then $d > 0$. The utility function may also be expressed directly for Z :

$$U(Z) = Z - bZ^2, b > 0 \quad (6)$$

The application of this type of analysis to the problem of lone wolf suicide terrorism, when fully worked out, promises to generate a number of important insights that may not attend the application of more orthodox analytical approaches:

1. The analysis of preference orderings and optimal portfolio selection on the basis of two moments of the underlying distribution may be usefully applied to the study of terrorism (see Phillips (2009; 2010)). However, it might be useful to think of the lone wolf suicidal terroristic agent as being engaged in a type of behaviour where the mean and variance of the underlying payoffs are infinite. The specification of quadratic expected utility may be useful as a starting point for analysis because it can be shown that the mean-variance analysis of the relevant choice problem can be extended to a scenario where the mean and variance of payoffs are infinite (Ohlson 1977). The lone wolf suicidal terroristic agent may therefore still operate in a manner consistent with the axioms of expected utility even though his behaviour appears to be irrationally extreme.

³ That this can be measured in any units is a fundamental advantage of the Arrow-Pratt measures of risk aversion that underlie analyses of this sort.

2. Given this, the equilibrium weights assigned by the aggregate of lone wolf terroristic suicidal agents to the range of targets or attack methods should be determinable, at least approximately. Ohlson (1977, p.583) demonstrates how the equilibrium weights and equilibrium relationship, which is similar analogically to that developed by Phillips (2010), are maintained even when the mean and variance of payoffs are not finite. The computation of the weights assigned by the aggregate of lone wolf terroristic suicidal agents to particular types of targets or attack methods would be a substantial analytical achievement that would remove some of the uncertainty that is created by this type of agent. The availability of relevant data—real and simulated—presents an obstacle but one that is not impossible to overcome.
3. Importantly, satiation—which is a property of the quadratic utility function—or a point where the objective function of the lone wolf terroristic agent reaches a maximum is likely to occur within relevant ranges of the mean and variance of the aggregate of terroristic attacks. That is, given the mean and variance of targets and attack methods (and the associated fatalities) that are observed to characterise all terroristic operations, the objective function of the lone wolf suicidal terroristic agent is likely to reach a maximum at a point that lies within a small number of standard deviations from the mean. Formal working through of this point will draw upon the analysis presented by Wipperfurth (1971).
4. Negotiation with lone wolf suicidal terroristic agents may not be possible and government concessions may not be relevant given the non-finiteness of the agent's expected payoffs. However, this being said, the behaviour of the agent is, within the analytical framework described here, consistent with the axioms of expected utility and the response to changes in the underlying distribution of payoffs must remain rational. The policies of governments and their security agencies should still induce substitution effects (among targets and attack methods) on the lone wolf suicidal terroristic agent.

These points are by no means exhaustive and much work remains to place them on a sound analytical-theoretical footing. However, the application of quadratic utility and mean-variance analysis does hold the promise of providing a starting point for the economic analysis of lone wolf suicide terrorism. Of special interest are the ways in which the properties of quadratic utility may be turned to the advantage of the defence economist even if those same properties may have been undesirable to some financial economists. Satiation within a narrow range of the mean and variance of the fatalities generated by the aggregate of terroristic operations is a potentially important insight. For the lone wolf suicide terrorist characterised by the utility theoretical makeup presented in this section, satiation and subjectively infinite payoffs may be generated by terroristic operations that do not by any means lie in the extreme of the distribution that characterises the aggregate of terroristic operations.

IV. CONCLUSIONS

Lone wolf suicide terrorism presents important challenges to defence economics. In this paper, an attempt has been made to set down a preliminary structure that may provide the traction necessary for defence economists to commence an analysis on a larger scale. The application of quadratic utility and mean-variance analysis may be a useful place to start because of its applicability in situations where means and variances of the payoffs are infinite. Future research must be concentrated on the formal working through of the preliminary structure presented herein. Such an undertaking may not only confirm the validity of some of the points hypothesised in this paper but will almost certainly generate additional important insights.

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