



Research Article

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The Deferral of Attacks: SP/A Theory as a Model of Terrorist Choice when Losses Are Inevitable

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Abstract: When a terrorist group's aspirations far exceed the outcomes that can be expected to result from any of the available attack methods, an outcome below the terrorist group's aspiration level is *inevitable*. A primary prediction of SP/A theory when applied to the study of terrorist behaviour is that when losses are inevitable the terrorist group will be risk averse and inclined to defer further action until expected outcomes improve, new attack method innovations are developed or the memory of the event that shaped aspirations has faded sufficiently that the aspiration level can be 'reset'. This complements existing predictions of loss aversion and risk seeking behaviour over the domain of *avoidable* losses and provides a starting point for developing explanations for patterns of behaviour that are observed in the terrorism context, including pauses in violence, even during brutality contests, and time-lags between terrorist attacks.

Keywords: SP/A Theory, Terrorist Behaviour, Risk, Uncertainty, Inevitable Losses, Aspiration, Brutality, Violence, Contests, Attacks, Avoidable Losses

1 Introduction

When terrorists perpetrate actions, they may be interested in different outcomes, including the number of injuries and fatalities that an action inflicts, the identities of particular victims, the significance of the attention that the action receives in the media and the responses of governments or law enforcement agencies. The outcomes of actions are not certain and may diverge from what was planned, aspired to or expected. In general, therefore, each prospective action is a risky prospect defined by its possible outcomes x_i and their probabilities p_i where $(p_1 + p_2 + \dots + p_n = 1)$. In economics and decision theory, there are several models of the process of ordering preferences over alternative risky prospects. These models include prospect theory (Kahneman & Tversky 1979), stochastic dominance (Hadar and Russell 1969; Hanoch and Levy 1969; Rothschild and Stiglitz 1970 & 1971; Meyer 1977a & 1977b; Levy 1992), mean-variance analysis (Markowitz 1952) and expected utility theory (von Neumann & Morgenstern 1947) and its generalisations. Each of these models can be used to determine preference orderings over alternative terrorist actions to develop a picture of the types of decisions and patterns of behaviour that might be observed if terrorist behaviour is somewhat reflected in one or more of the theoretical frameworks.

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Because each of the models is based on a theory of behaviour, a computed preference ordering can be complemented by a description of how a choice might be made and how choices may change as circumstances change. This computation-narrative duality is the core contribution that the application of decision theory brings to terrorism studies.

A major part of the motivation for applying models of the decision-making process to terrorist behaviour is the opportunity to provide analysis and explanation for observed patterns of behaviour that are often overlooked but which have significant implications for law enforcement and security. For example, terrorist groups almost never concentrate solely on one particular attack method but instead use several different attack methods over time or even during a single period. When attack methods are combined the expected outcomes improve while the risk borne by the terrorist group decreases (Phillips 2009).¹ The implications of this are important but easily overlooked. The decision to combine different attack methods can be explained in terms of the advantages that derive from diversification in any context in which the payoffs to risky prospects are not perfectly positively correlated with each other. As Phillips (2009, 2013, 2016) has shown, dynamic management of and adjustment to innovations in the risk-reward trade-off motivates a series of behavioural patterns that are predicted and explained by the mean-variance framework. Beyond computing the opportunity set and determining the attack method combinations that might be preferred by terrorist groups with higher or lower degrees of risk aversion, a descriptive account of terrorist behaviour can also be developed.

As might be expected, behavioural models such as prospect theory provide further scope for developing descriptions of the decision-making process in a given context as well as the capability of pure computation of preference orderings over alternative risky prospects. Technically, the preference orderings that emerge from each model diverge to the extent that particular factors or parameters are included, omitted or emphasised to differing degrees. Taken together, the ‘matrix’ of preference orderings derived from each model complement each other and show how different aspects may influence terrorist choice in some direction or the other. Descriptively, prospect theory includes several factors that are not included in other decision-making models. Phillips & Pohl (2014, 2017) have shown how the reference point concept that lies at the heart of prospect theory can be used to explain patterns of copycat behaviour among terrorists as well as ‘contest’ behaviour where terrorists or terrorist groups attempt to supersede the outcomes achieved by their predecessors.

While expected utility theory and prospect theory have, understandably, attracted the most attention, another model of the decision-making process has quietly developed outside of the spotlight accorded to its better known counterparts. This is Lopes’ (1987) *SP/A* theory. Similar to prospect theory in some ways and also exhibiting some parallels with Quiggin’s (1982) generalisation of expected utility theory, *SP/A* theory provides an interesting lens through which to view terrorist choice. The decision-maker depicted within the model is one who is driven by fear and hope to focus on either the security (*S*) afforded by some alternative or the potential (*P*) upside promised by others. Any decision that would be based on an evaluation of alternatives and their security-potential is impacted by the drive towards fulfilling an aspiration (*A*), so much so that aspirations can overwhelm an evaluation and lead the decision-maker to choose quite differently from what an assessment of payoffs and probabilities would prescribe.

The decision-making process that is described by *SP/A* theory has several unique features that allow us to explore the role of aspirations in shaping terrorist behaviour and, in particular, the impact on choice of aspirations that are so high relative to the outcomes that can be expected from the available attack methods that an outcome that does not meet the aspiration level is inevitable. Prospect theory predicts that decision-makers will be risk seeking in the domain of losses.² A riskier attack method promises a greater chance of an outcome above the reference point, and the terrorist group will become more risk seeking as long as losses are still avoidable (Phillips & Pohl 2014). However, when losses are inevitable, so that there is no

¹ Simply, terrorists achieve better expected outcomes with lower risk than what we would think if we restricted our focus to single attack methods.

² Losses are outcomes that lie below the reference point or aspiration level. For example, a terrorist with a reference point of 10 fatalities treats an outcome of 5 fatalities as a loss.

possibility of avoiding the loss regardless of how much risk is taken, what will the terrorist group choose to do? *SP/A* theory predicts that the terrorist group will choose to defer its action. With this insight, *SP/A* theory complements the existing application of decision theory in the terrorism context.

2 From Orthodox Models to *SP/A* Theory

Despite there being several competing models of the process of decision-making under conditions of risk and uncertainty, there has long been a consensus that decision-makers distort the outcomes and probabilities of risky prospects in systematic ways. A lot of work has been directed towards developing a psychological explanation for this behaviour, especially the non-linear weights that decision-makers systematically apply to probabilities and outcomes.³ *SP/A* theory derives non-linear probability weighting from the ‘emotions’ of hope and fear rather than ‘perceptions’ and so represents a distinct behavioural model of the decision-making process and a unique alternative to orthodox theories. Like the other behavioural models and generalisations of expected utility theory, *SP/A* theory emerged from the realisation that decision-makers weight probabilities in a non-linear way, something that had first come to the attention of economists during the 1950s as a potentially significant anomalous violation of expected utility theory.

Being first and foremost a mathematical theory, it is not surprising that expected utility theory faced some early challenges in the empirical domain.⁴ The strongest challenges initially came from Allais (1953) and Ellsberg (1961) who cast doubt upon the empirical validity of the property known as ‘linearity in the probabilities’, a property embedded in von Neumann and Morgenstern’s independence axiom (Machina 1987). The independence axiom states that for three lotteries, L_1 , L_2 and L_3 , if the decision-maker prefers L_1 to L_2 , denoted by $L_1 > L_2$, then for all $p \in (0,1)$:

$$pL_1 + (1-p)L_3 > (1-p)L_3$$

A decision-maker whose preferences obey the independence axiom will accord equal weights to the probability of each possible outcome of a risky prospect. To see how a violation of this axiom may emerge in the terrorism context consider a terrorist who must choose between actions A and B in scenario 1 and between actions C and D in scenario 2:

Scenario 1:

A: certain to inflict 1 fatality; or

B: 89% chance of 1 fatality, 10% chance of 5 fatalities and 1% chance of zero fatalities

Suppose that the terrorist prefers the action, A, that will certainly inflict 1 fatality. Now consider scenario 2:

Scenario 2:

C: 89% chance of zero fatalities, 11% chance of 1 fatality

D: 90% chance of zero fatalities, 10% chance of 5 fatalities

³ Research has also been directed towards investigating the possibility of a neurological explanation (Berns *et al.* 2008). In this regard, it is interesting to note the systematic behaviour found to characterise animals’ choices over uncertain outcomes (Battalio *et al.* 1985).

⁴ Von Neumann and Morgenstern’s (1947) expected utility theory, derived on the basis of the axioms of completeness, transitivity, continuity and independence, is the traditional theory of rational decision-making under risk and uncertainty. The theory says that decision-makers consider outcomes and the utility or satisfaction they associate with each outcome. Von Neumann and Morgenstern proved that there exists a class of functions that transforms outcomes into utility numbers in a manner that preserves the decision-maker’s underlying preference structure. The utilities are weighted by the probability that the outcome will occur and summed over all outcomes to obtain the expected utility for a risky prospect. Risky prospects are compared on the basis of expected utility and the one with the highest expected utility number will be selected (or should be selected, depending on whether the theory is interpreted as predictive or prescriptive). See Ellsberg (1954) for further exposition and Fishburn (1989) for a ‘retrospective’ review. Fishburn’s (1989, p.138) comments on the independence axiom are noteworthy.

Suppose that the same terrorist now prefers the action D. This pair of choices, A and D, violates the independence axiom.⁵ This type of behaviour implies that rather than treat each probability for each outcome as being equally important, decision-makers underweight large probabilities and overweight small probabilities (Allais 1953; Ellsberg 1961; Lopes 1987; Tversky & Kahneman 1992; Camerer & Ho 1994; Wu & Gonzalez 1996; Prelec 1998; Gonzalez & Wu 1999; Abdellaoui 2000; Bruhin *et al.* 2010). In the terrorism context, therefore, terrorists are likely to accord greater weight to unlikely outcomes and less weight to more likely outcomes. Rather than the probability, p_i , of each outcome, x_i , entering directly into the terrorist's decision-making process, a more accurate description of the terrorist's decision-making process is one in which the probabilities of outcomes are themselves weighted or transformed by some function $w(p)$ to reflect the systematic underweighting of large probabilities and overweighting of small probabilities.⁶ Although an exact specification of the probability weighting function is still the subject of ongoing research it is clear that any such function must be non-linear and (inverse) S-shaped, as depicted in Figure 1.

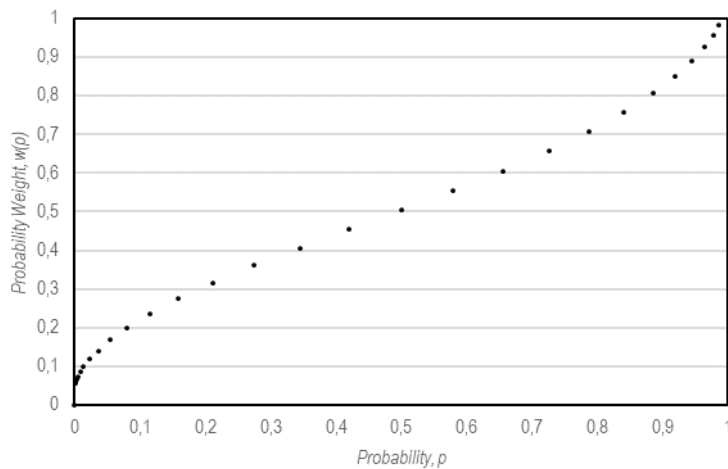


Figure 1: The (Inverse) S-Shaped Probability Weighting Function

Once it became clear that the unequal weighting of probabilities by decision-makers was systematic, research in psychology and economics responded by turning in two main directions.⁷ Along one path, efforts were made to incorporate non-linear functions of probabilities into the model (Machina 1987, Starmer 2000). Generalisations of expected utility theory have demonstrated that it does not rely upon the independence axiom if preferences are ‘smooth’ (Machina 1982), reversed the roles of payoffs and probabilities (Yaari 1987), and developed the concepts of expected utility (Quiggin 1982) and non-additive probabilities (Schmiedler 1989). Along the other path, new behavioural models were developed, most prominently prospect theory (PT, Kahneman & Tversky 1979) and cumulative prospect theory (CPT, Tversky & Kahneman 1992). CPT extends PT to deal with risky prospects with multiple outcomes under conditions of

⁵ To see how this pair of choices A and D is inconsistent, it is helpful to break A into two parts (89% chance of 1 fatality and 11% chance of 1 fatality). Now the 89% chance in A and B cancel out. If the decision-maker chooses A, the revealed preference is for an 11% chance of 1 fatality over a 10% chance of 5 fatalities and 1% of zero fatalities. In the second scenario D can also be broken down into 89% chance of zero fatalities, 1% chance of zero fatalities and 10% chance of 5 fatalities. Viewed in this way, we can see that once the common elements are cancelled out, option A is the same as option C and option B is the same as option D. To choose A (or B) and then choose D (or C) is inconsistent.

⁶ There is a clear distinction between weighted or transformed probabilities or ‘decision weights’ and the probabilities themselves. Kahneman and Tversky (1979, p. 280) stress, “...decision weights are not probabilities: they do not obey the probability axioms [of Kolmogorov (1933)] and they should not be interpreted as measures of degree of belief”.

⁷ A related, but arguably distinct, direction is the development of ‘regret theory’ (Bell 1982; Loomes & Sugden 1982).

both risk and uncertainty while preserving stochastic dominance.⁸ While CPT incorporates several aspects of the decision-making process that are overlooked by expected utility theory (including loss aversion, reference point dependence, diminishing sensitivity, risk seeking in the domain of losses, and risk aversion in the domain of gains), each ranks alternative risky prospects using a single statistic (expected utility or prospect value), obtained by evaluating risky prospects via a utility function.

Expected utility theory, CPT and stochastic dominance have all been applied to the analysis of terrorist choice (Landes 1978; Sandler *et al.* 1983; Phillips 2009; Phillips & Pohl 2014; Phillips & Pohl 2017).⁹ Compared to these models, *SP/A* theory is distinct with regard to the explanation it offers for non-linear probability weighting and in terms of the criteria that the *SP/A* decision-maker applies to the evaluation and selection of risky prospects. *SP/A* theory depicts the choice from among alternative risky prospects as an increasing function of the two *separate* criteria, security-potential (SP) and aspiration level (A):

$$SP/A = f[SP, A].$$

The security-potential (SP) criterion is the result of a process of evaluating outcomes and probabilities. The aspiration (A) criterion is simply the probability that a risky prospect will yield an outcome equal to the aspiration level or higher. The *SP/A* decision-maker considers both criteria in reaching a final decision. This model of the decision-making process has found application in modern theoretical developments in behavioural economics, especially the development of behavioural portfolio theory (Shefrin & Statman 2000; Das *et al.* 2010). Like CPT, in *SP/A* theory decision-makers weight the probabilities unequally in the manner that we have discussed above. Also like CPT, an aspiration level or reference point plays a role in shaping the *SP/A* decision-maker's assessment. As Lopes (2013) points out, the decision-maker is focussed on the probability of achieving an outcome *at least* as large as the aspiration level. The aspiration level, as well as being a reference point concept, is also a 'threshold' concept designed to reflect decision-makers' desires to gain 'at least'. Thresholds are reminiscent of 'safety first' principles (Roy 1952; Telser 1956; Kataoka 1963) and play an important role in mental accounting (Shefrin & Statman 2000; Das *et al.* 2010). Unlike CPT, *SP/A* theory allows a decision-maker to assess a risky prospect in three different ways: (1) security-minded; (2) potential-minded; or (3) 'cautiously optimistic' (Lopes & Oden 1999). Most importantly, the aspiration level is not incorporated into the decision-maker's value or utility function, but rather is distinct and may either reinforce or override the *SP* assessment of a risky prospect.

Whereas Tversky & Kahneman (1992) explain their non-linear probability weighting function in terms of diminishing sensitivity, *SP/A* theory develops an alternative psychological explanation which, resembling Quiggin's (1982) optimism-pessimism dichotomy, is based on the concepts of 'diminishing attention', 'security-mindedness' and 'potential-mindedness'. In Figure 2, probabilities are *decumulative* (Lopes & Oden 1999). They represent the probability of achieving at least the associated outcome, ranked from worst possible (e.g. at least zero fatalities with probability 1) to the best possible (e.g. at least a number of fatalities higher than the maximum possible with probability zero) moving from right to left. The convex (concave) function in Figure 2 shows the probability weights accorded by a security-minded (potential-minded) decision-maker. Weighting is shaped by the amount of attention that the decision-maker gives to different outcomes. The security-minded decision-maker pays more attention to the worst outcomes. The potential-minded decision-maker pays more attention to the best outcomes. The (inverse) *S*-shaped weighting function shows the probability weights accorded by a cautiously optimistic decision-maker whose attention is somewhat divided between best and worst outcomes depending on just how cautious he or she happens to be.

⁸ Tversky & Kahneman (1992) are in fact dismissive of stochastic dominance, and indeed Birnbaum *et al.* (1999) have highlighted the frequency with which decision-makers violate stochastic dominance.

⁹ Utility theory, which is a logical but not mathematical theory of choice under conditions of certainty, has long been applied to the economic analysis of terrorism. For example, see Enders & Sandler (2002) or Frey & Luechinger (2003).

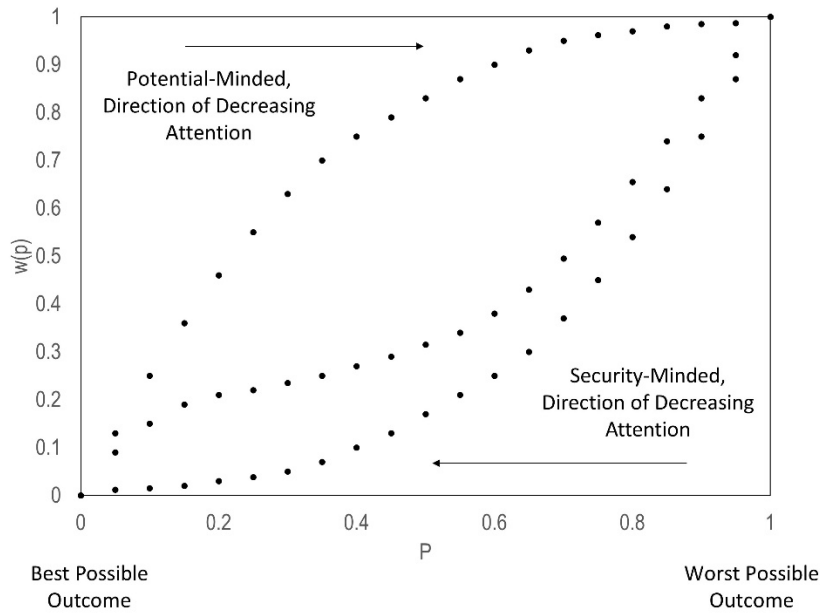


Figure 2: Security-Mindedness, Potential-Mindedness and Cautious Optimism

As with prospect theory (Barberis 2013), the psychological explanations for non-linear probability weighting in *SP/A* theory represent decision weights rather than erroneous beliefs, meaning that the decision-maker understands the tails of the probability distribution. As Lopes (2013, p.7) explains, the probability weights do not “reflect errors in assessing probabilities. Instead, they only suppose that people’s values for security or potential can be expressed by how much attention is paid to the various regions of the lottery”. The decision-maker overweights and underweights, but understands, the tails of the probability distribution. This is so for *any* distribution (Barberis 2013).¹⁰

3 The Formal Structure of *SP/A* Theory

SP/A theory, then, is a behavioural model that aims to describe how decision-makers choose from among alternative risky prospects. The main points are: (1) decision-makers weight probabilities non-linearly; (2) the decision model that encompasses these individual and situational variables is characterised by two criteria: security-potential (*SP*) and aspiration (*A*); (3) the decision-maker’s choice is an increasing function of the combined criteria, $SP/A = f[SP, A]$; and (4) the aspiration level may reinforce or override the *SP* assessment. To see how these features work to shape decision-making, we present a short formal discussion of *SP/A* theory.

The *SP* component is where the decision-maker evaluates each prospect on the basis of its expected outcomes and the degree of uncertainty that characterises them (Lopes 1995; Lopes & Oden 1999; Rieger 2010).¹¹ Simply, the utility of each outcome is weighted by a non-linear decision weight and the sum is taken over all outcomes to arrive at the *SP* evaluation:

$$SP = \sum_i (h(D_i) - h(D_{i+1}))u(x_i)$$

¹⁰ Regardless of the nature of the distribution that shapes outcomes, the decision-maker might be able to introduce skewness by adopting various strategies (Barberis 2013).

¹¹ This can also be expressed as a Lebesgue-Stieltjes integral of the following form (He & Zhou 2013), where $F_X(\bullet)$ is the cumulative distribution function of X : $V(X) = \int_0^{\infty} x d[-w(1-F_X(x))]$

Here $D_i = \sum_{n=i}^N p_n$ is the decumulative probability, $u(x_i)$ is a concave utility function and $h(D)$ is a non-linear decumulative weighting function that takes the form (Lopes & Oden 1999, p.290):

$$h(D) = wD^{q_s+1} + (1-w)[1-(1-D)^{q_p+1}].$$

Here the parameters $q_s \geq 0$, $q_p \geq 0$ and $0 \leq w \leq 1$ reflect a decision-maker's security-mindedness, potential-mindedness or cautious optimism respectively. In terms of Figure 2, these parameters determine convexity, concavity or (inverse) 'S-shaped-ness', respectively. The function wD^{q_s+1} is convex and reflects security-mindedness. The function $1-(1-D)^{q_p+1}$ is concave and reflects potential-mindedness. If the decision-maker is completely security-minded, $w = 1$. If the decision-maker is completely potential-minded, $w = 0$. Cautious-optimism is reflected by $0 < w < 1$. As the assessment of the possible outcomes proceeds either from the best to worst outcomes (potential-minded) or from the worst to best outcomes (security-minded), the decision-maker pays less attention to successive outcomes at rates q_s and q_p . Most decision-makers combine aspects of both security-mindedness and potential-mindedness. That is, they are cautiously optimistic to some degree.

Significant evidence has been gathered to support the conclusion that decision-makers are reluctant (keen) to take actions that entail the likelihood of failure (success) measured with respect to an aspiration (Diecidue & van de Ven 2008). By keeping the A criterion distinct, SP/A theory allows aspirations to reinforce or override other dimensions of the decision-maker's preferences. When the aspiration level is low relative to the range of likely outcomes, aspirations reinforce security-mindedness. When aspirations are high relative to the range of likely outcomes, aspirations reinforce potential-mindedness. However, when aspirations are so high that an outcome below the aspiration level is inevitable, aspirations override potential-mindedness and reinforce security-mindedness.¹² This subtle treatment emerges from what is a very basic technical feature of SP/A theory. Formally, the A component is simply the likelihood that the risky prospect will yield outcomes equal to or greater than an aspiration level, α :

$$A = p(x \geq \alpha).$$

If there are just two prospects, i and j , possible outcomes of the decision-making process include: (1) if i and j both have the same likelihood of generating $x \geq \alpha$, the prospect with the higher SP value will be selected; (2) if i has both the higher SP value and the higher A value, then i will clearly be favoured; (3) if i has a *slightly* higher SP value than j but fails to meet the aspiration level while j , although having a slightly lower SP value does meet the aspiration level, then j would be selected over i ; (4) if i has a *much* higher SP value than j but fails to meet the aspiration level while j has a much lower SP value than i but does meet the aspiration level, the SP/A assessments contradict each other. In this case, either i or j might be selected; (5) if it is certain that i will generate an outcome that meets the aspiration level while it is uncertain that j will generate such an outcome, i would be selected over j ; (6) if there is no possibility that the aspiration level will be met by either i or j , the decision-maker would prefer to avoid both prospects.

As an example, consider a cautiously optimistic terrorist decision-maker with $w=0.6$, $q_s = 4$ and $q_p = 4$ who must choose between two alternative (hypothetical) terrorist actions, i and j where the decumulative probabilities for each of the actions are presented in Table 1. Action i has a lower expected outcome of 15 fatalities and less variability or risk (3 fatalities) while action j has a higher expected outcome of 20 fatalities with more variability or risk (4 fatalities). Variability or risk does not enter directly into the decision-making framework but it does shape the distribution of outcomes. For each action, the worst possible outcome is zero fatalities. For action i , the best possible outcome is 35 fatalities and for action j the best possible outcome is 45 fatalities. The cautiously optimistic decision-maker's SP value for $i=0.6703$ whilst the corresponding value for $j = 0.9061$. If the aspiration level $\alpha = 15$, it can be seen from Table 1 that j provides a

¹² Using the terminology of prospect theory, the aspiration level reinforces risk aversion over the domain of gains and reinforces loss aversion over the domain of losses. Unlike prospect theory, reinforcing loss aversion over the domain of losses may generate risk seeking or risk aversion depending on the magnitude of the losses being considered.

greater possibility of achieving *at least* the aspiration level (0.89 versus 0.50). Since it has both the higher *SP* value and the higher *A* value, *j* will be preferred.

When the security-mindedness or potential-mindedness of the terrorist decision-maker changes, it is possible that a different action may be preferred on the basis of the *SP* assessment. Because its outcomes are less variable, action *i* is less risky than action *j*. It should not be surprising to find that if the decision-maker is completely security-minded ($w = 1$), *i* becomes the action with the higher *SP* value. When this is the case, the *SP* value for $i = 0.1747$ whilst the corresponding value for $j = 0.1526$. If the aspiration level remains at $\alpha = 15$, the *SP* evaluation favours *i* but *j* is still much more likely to fulfil the decision-maker's aspirations. As such, the decision-maker would choose *j* despite the higher risk. Just as in prospect theory, the decision-maker takes more risk to avoid a loss. However, when aspirations reach such a high level that neither prospect has any possibility of producing an outcome that exceeds the aspiration level, the decision-maker would prefer to avoid both prospects. In this case, aspirations reinforce loss aversion but do so against the backdrop of risk aversion.

Table 1: Outcomes and Decumulative Probabilities, Hypothetical Actions

Outcomes, Worst to Best (Expected Fatalities)	Decumulative Probability (i)	Decumulative Probability (j)
At least... 0 fatalities	1	1
1	0.9999985	0.9999990
2	0.9999927	0.9999966
3	0.9999683	0.9999893
4	0.9998771	0.9999683
5	0.9995709	0.9999116
6	0.9986501	0.9997674
7	0.9961696	0.9994230
8	0.9901847	0.9986501
9	0.9772499	0.9970202
10	0.9522096	0.9937903
11	0.9087888	0.9877755
12	0.8413447	0.9772499
13	0.7475075	0.9599408
14	0.6305587	0.9331928
15	0.5000000	0.8943502
16	0.3694413	0.8413447
17	0.2524925	0.7733726
18	0.1586553	0.6914625
19	0.0912112	0.5987063
20	0.0477904	0.5000000
...
35	0.0000	0.0062097
...	0.0000	...
At least 45 fatalities	0.0000	0.0000

4 SP/A Theory and Terrorist Attack Method Choice

In perpetrating a terrorist action, terrorist groups choose an attack method or combination of attack methods. This is one of the choices that can be analysed from the perspective of decision theory. Although the specific nature of a terrorist action is unique, the choice of attack method must initially be made from a relatively small set of commonly deployed actions. These are reflected in the categories that constitute databases such as the Global Terrorism Database (GTD). Each attack method is characterised by an average or expected number of fatalities and a standard deviation that indicates the possibility that the actual outcome of any single instance will diverge from what was expected. Table 2 shows that the attacks perpetrated during 2016 are characterised by a risk-reward trade-off across methods: greater chances that the actual outcome will diverge from what was expected are associated with better expected outcomes.

Table 2: Attack Methods 2016, Least Risky to Most Risky¹³

Attack Method	Number of Incidents	Average Fatalities Per Attack	Standard Deviation of Outcomes
Hijacking	41	1.14	1.79
Assassination	779	2.32	6.11
Hostage-Taking	1,086	2.38	6.64
Armed Assault	2,579	2.68	9.51
Bombing	6,655	2.69	9.54
Facility/Infrastructure	654	3.60	15.70
Unarmed Assault	64	5.96	20.23

Orthodox expected utility theory predicts that the terrorist group will choose the attack method with the highest expected utility, though not necessarily the highest expected value. In Table 2, unarmed assault has the highest expected value but also the most variable outcomes.¹⁴ A risk averse decision-maker trades off higher expected outcomes with greater risk. Depending on the nature of the terrorist group's utility function and, in particular, the level of risk aversion, the attack method with the highest expected outcomes may not be assigned the highest expected utility. For example, a relatively risk seeking decision-maker with preferences described by logarithmic utility prefers unarmed assault. For a more risk averse decision-maker whose preferences are described by 'power' utility, hijacking is the preferred attack method followed by assassination, hostage-taking and unarmed assault.¹⁵ Applying utility theory avoids incorrectly concluding that all terrorists will prefer the attack method with the highest expected outcomes. Observed choices are more diverse than this.

Furthermore, terrorist groups often combine several different attack methods over time, which has important implications for the expected payoffs that accrue to a terrorist group and the risks that the group had to bear to obtain them. Mean-variance (portfolio) analysis is well suited to analysing this situation. The method simplifies the decision calculus to an assessment of alternatives based on the expected payoff and standard deviation, $U=f(\mu,\sigma)$. When combinations of risky prospects are considered, the opportunity set can be calculated in such a way that the standard deviation of individual prospects is accounted for *as well* as the correlation of the outcomes between different risky prospects. The risk-reward trade-off that emerges is positive, as reflected in the individual prospects listed in Table 2. However, when correlation is taken into account the risk-reward trade-off is also found to be concave, producing higher expected payoffs at each level of risk than would be available if combining attack methods was not possible.

¹³ There were 915 attacks where the attack method is listed as 'unknown'. These have not been included.

¹⁴ This is the category under which the GTD records 'vehicle attacks' where the terrorist uses a vehicle to inflict fatalities on civilians. In all previous years, this category has had a much lower average outcome (less than 1 fatality per attack).

¹⁵ This is with the risk aversion coefficient set to 3, the mid-range of the 1 to 5 commonly accepted values. In contrast, the logarithmic utility risk aversion coefficient equals 1 by construction.

The concave curve in Figure 3 is the opportunity set consisting of all possible combinations that can be formed from the available attack methods. The decision-maker's choice of combination depends on the degree to which the decision-maker is risk averse. Combinations that have lower risk are located in the lower left of the opportunity set. Combinations that have higher risk are located in the upper right of the opportunity set. Low (high) risk combinations can each contain high (low) risk individual attack methods. That is, a lower risk combination may still be constituted to some degree by the highest risk attack method and vice versa. However, for the most part, lower (higher) risk combinations will be more heavily weighted towards lower (higher) risk individual attack methods. In Figure 3, therefore, a more risk averse terrorist group would choose an attack method combination from the lower left of the set and that combination would be more heavily constituted by lower risk attack methods. A less risk averse terrorist group would choose an attack method combination from the upper right of the set and that combination would be more heavily constituted by higher risk attack methods.

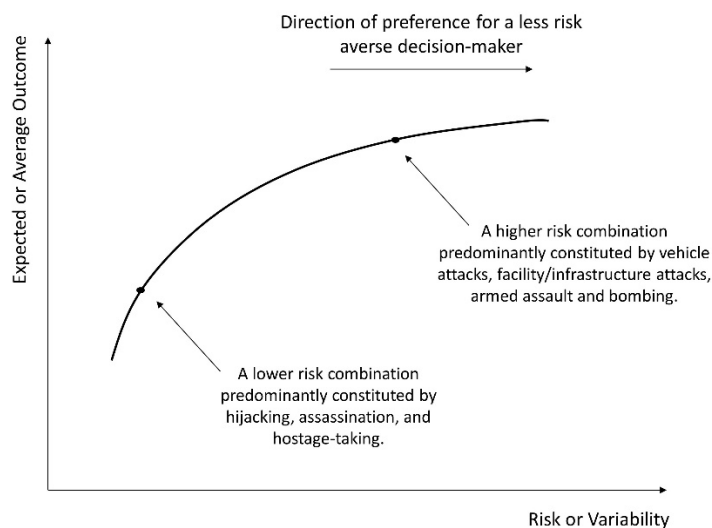


Figure 3: Mean-Variance Analysis, Opportunities and Choices

Together, expected utility theory and mean-variance analysis can provide explanations for patterns of behaviour involving individual risky prospects and combinations of them and incorporate factors such as expected outcomes, risk, risk preference and correlation structure into formal frameworks that can be used to better understand terrorist choice. These advances can be augmented considerably by exploring the ways in which behavioural models of the decision-making process apply in the terrorism context. Prospect theory is the most well-known descriptive-behavioural model of the decision-making process. In addition to providing a method for computing preference orderings that reflect a number of aspects of observed behaviour that are not represented in expected utility theory or mean-variance analysis, prospect theory provides a richer framework for developing insights into the actual decision-making process. Much of the innovation that prospect theory represented is encompassed in its S-shaped utility function (Figure 4), which depicts a reference point, a domain of losses in which the decision-maker is risk seeking and a domain of gains in which the decision-maker is risk averse.

In prospect theory, the reference point is a critical part of the evaluation process. The terrorist decision-maker chooses an attack method based on an evaluation in which the outcomes of a predecessor or a rival are accorded a great deal of significance and shape the attack method choice considerably. The reference point determines the domain of gains and losses and influences the relative attractiveness of alternative

attack methods.¹⁶ Importantly, if the terrorist group's reference point is high relative to average outcomes that are usually generated by the attack methods listed in Table 2, the terrorist group confronts a relatively broad domain of losses. The opposite is true for reference points that are low relative to the average outcomes of the available attack methods. For example, consider a reference point of 25 fatalities. Given the average and standard deviation of the attack methods listed in Table 2, reaching this reference point will not be easy and most outcomes are expected to lie below it. Conversely, a reference point of just 2 fatalities falls much more within the likely reach of a terrorist group using any one of the available attack methods.

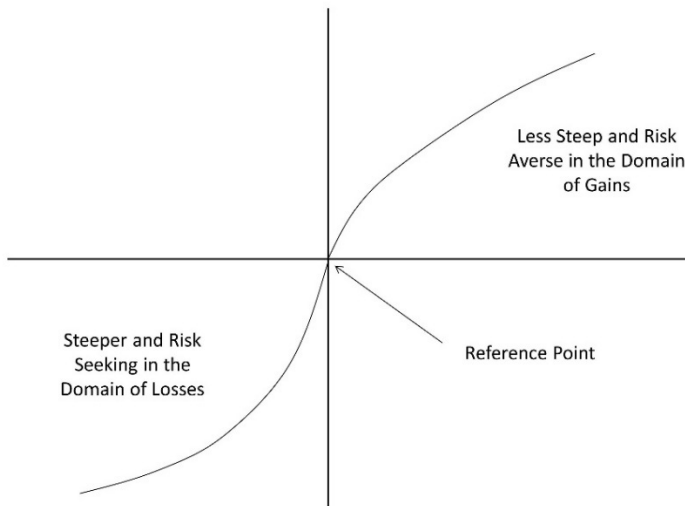


Figure 4: The S-Shaped Utility Function of Prospect Theory

Prospect theory predicts two main types of behaviour. In the first instance, in the domain of avoidable losses the terrorist group will be risk seeking and choose an attack method with higher and more variable outcomes. As the reference point increases, the terrorist group must take more risk to generate a possibility of an outcome above the reference point and avoid incurring a loss. In the second instance, risk aversion over the domain of gains predicts that the terrorist group will choose the least risky attack method that still provides an attractive likelihood of generating an outcome in excess of the reference point. This may or may not be the attack method with the lowest level of risk, but it will certainly not be the attack method with the most variable outcomes.

SP/A theory complements prospect theory by allowing us to analyse decision-making in the domain of *inevitable* losses. In choosing an attack method, the terrorist group may hold such lofty aspirations relative to the possible outcomes that it confronts inevitable (unavoidable) losses. Even the choice of the riskiest attack method will fail to produce an outcome that exceeds aspirations. As discussed, prospect theory generally predicts risk seeking in the domain of losses. Because the utility function of *SP/A* theory is allowed to undulate over the domain of gains and losses, different preferences may dominate over different ranges of outcomes and probabilities and the decision-maker may switch from being risk averse to being risk seeking and back to risk averse as gains and losses of varying magnitudes are considered. Rather than simply providing a point of inflection that partitions the domain of gains and the domain of losses, the aspiration level in *SP/A* theory actively shapes the utility function by reinforcing or overriding aspects of the decision-maker's preferences, especially loss aversion. When aspirations are low relative to

¹⁶ Phillips & Pohl (2014, 2017) explored the implications for terrorist choice when the reference point is an outcome achieved by another terrorist.

expected outcomes, aspirations reinforce risk aversion over the domain of gains. When aspirations are high relative to the expected outcomes, aspirations reinforce loss aversion. However, whereas high aspirations reinforce risk seeking when losses are still avoidable, aspirations instead override risk seeking to generate risk aversion, and thus the deferral of action, when they are sufficiently high to make losses inevitable. Formally, the pattern of decision-making that we can expect is depicted by the type of utility functions discussed by Bosch-Doménech & Silvestre (2006), Diecidue & van de Ven (2008) and Rieger (2010). We can draw a *SP/A* utility function that splices a concave (risk averse) segment onto the lower left end of the prospect theory's S-shaped utility function, corresponding to the domain of inevitable losses. The resultant undulating utility function is drawn in Figure 5.

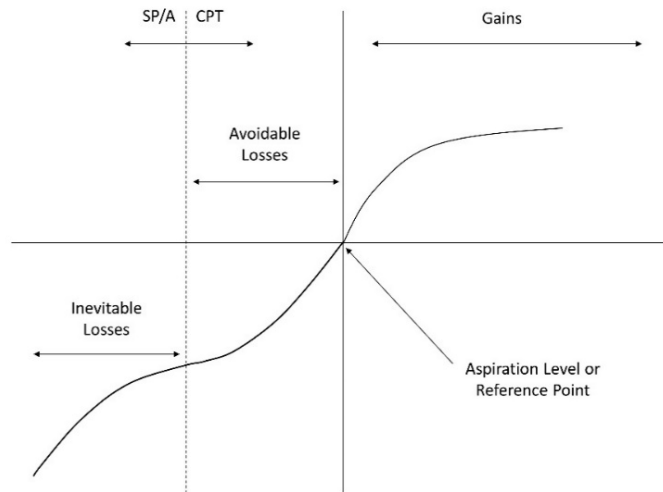


Figure 5: *SP/A*-CPT Concave-Convex-Concave Utility function

SP/A theory provides a theoretical explanation, drawn from foundational concepts of decision theory, for observations of risk averse behaviour and attack deferral when inflicted brutality or another relevant payoff rises to very high levels relative to the outcomes expected from the available attack methods. Before this point is reached, attacks take place at varying intervals. The average of these intervals, however, is predicted to be much shorter in duration than the deferral period that follows once the point of inevitable losses is reached. This is not a macro-level prediction but a prediction of a pattern of behaviour that should be expected within particular ‘contests’ when terrorist groups are referencing each other’s actions.

There are no existing empirical studies of *SP/A* theory in a terrorism context, but some elements of the predicted patterns of behaviour can be found in the results of studies of terrorist contests. For example, Caruso & Schneider (2013) studied contests between jihadist groups. The authors found strong positive correlation in the number of victims of terrorist attacks over time, indicating the type of referencing behaviour that we would expect. They also found variable time lags between attacks in each series. From such a starting point, it is reasonable to expect empirical work that draws specifically on *SP/A* theory to extend our understanding of contest behaviour among terrorist groups.

The predictions of *SP/A* theory should also hold when the desired outcome is not fatalities but media attention. The historical record of terrorism contains examples of groups that are known to have been involved in contests with each other, referenced each other’s behaviour and competed for publicity without necessarily maximising the number of fatalities that were inflicted. An important example occurred in Germany during the 1970s. Two groups in particular were known to have been competing with each other

for prominence: the Red Army Faction (RAF) and the 2nd of June Movement.¹⁷ As a first step towards an empirical analysis of the predictions of SP/A theory, we catalogued each attack perpetrated by these two groups for the period January 1970 to December 1979. There were 41 attacks in total. For each attack, we counted the total media coverage (measured in column inches, c") from the first reporting day following an event until no further reporting took place in each of three major daily newspapers: *Bild-Zeitung*, *Süddeutsche-Zeitung* and *Die Welt*. We have singled out a sub-period during which there was a 'back-and-forth' of attacks between the groups. This is the period from early 1974 to mid-1978.

The information is summarised by Table 3 which starts with an action by the RAF. It had been 45 days since the previous action. The next action in the series was by the 2nd of June Movement which took place 73 days later. The steady back-and-forth of actions between these two rival groups is punctuated by three significant pauses following: (1) the 2nd of June Movement's action on 27 February 1975 (the kidnapping of Peter Lorenz); (2) the RAF's action on 7 April 1977 (the assassination of Siegfried Buback); and (3) the run of actions by the RAF culminating with the action perpetrated on 5 September 1977 (the kidnapping and murder of Hanns Martin Schleyer). The Schleyer murder is also the culmination of the 'German Autumn'. We would expect each of these actions, which were followed by significant pauses, to have been actions that received very large amounts of media coverage. This is what we find. Although this is by no means an empirical verification of SP/A theory and the conclusions that we have drawn from applying the model to the terrorism context, it is a pattern of behaviour that is consistent with the predictions that emerge from the theory and a promising prelude to a more detailed empirical investigation.

Table 3: Actions Perpetrated by the Red Army Faction and the 2nd of June Movement, Germany

Date of Action	Perpetrator	Media Attention, c" (Bild-Zeitung)	Media Attention, c" (Süddeutsche-Zeitung)	Media Attention, c" (Die Welt)	Total Media Attention, c"	Days Between Attacks
24/03/1974	RAF	0	0	0		45
5/06/1974	2 nd of June Movement	0	0	0		73
26/08/1974	2 nd of June Movement	0	1.84	0	1.84	82
20/11/1974	RAF	71.31	0	59.28	130.59	86
30/01/1975	RAF	0	0	0	0.00	71
27/02/1975	2 nd of June Movement	3914.67	1681.77	2759.89	8356.33	28
16/10/1975	RAF	2.87	0	7.8	10.67	231
18/06/1976	2 nd of June Movement	0	0	0	0.00	246
4/09/1976	RAF	0	0	3.25	3.25	78
10/11/1976	2 nd of June Movement	40.93	0	0	40.93	67
8/01/1977	RAF	0	0	0	0.00	59
7/04/1977	RAF	772.65	679.88	1164.75	2617.28	89
30/07/1977	RAF	663.77	714.07	1188.46	2566.30	114
25/08/1977	RAF	121.21	143.52	192.09	456.82	26
05/09/1977	RAF	6118.37	6413.21	6141.41	18672.99	11
27/05/1978	2 nd of June Movement	425.71	0	0	425.71	264

¹⁷ Quotes from RAF members that support this can be found in Phillips & Pohl (2014). Also see Pohl (2015) and, especially, Pohl (2017).

5 Concluding Remarks

Encompassing the different dimensions of terrorist decision-making, including the choice to *defer* action, within a coherent overarching framework is a task towards which each of the extant models of decision-making under conditions of risk and uncertainty contributes its perspective and its particular piece of the puzzle. *SP/A* theory highlights and offers an explanation for certain aspects of observed terrorist behaviour that have yet to be adequately treated. Pauses in violence, even during brutal contests, emerge as predicted behaviour within the *SP/A* decision-making process when it is applied to terrorist choice. Whenever aspirations formed on the basis of the outcomes of previous actions are so high relative to the expected outcomes of the available alternatives that a loss is inevitable, aspirations reinforce security-mindedness and loss aversion and override any tendency towards risk seeking behaviour. Together, *SP/A* theory and prospect theory describe patterns of behaviour over the range of outcomes which, relative to an aspiration level, constitute inevitable losses, avoidable losses and gains.

References

- Abdellaoui, M. 2000. Parameter-free Elicitation of Utility and Probability Weighting Functions. *Management Science*, 46, 1497-1512.
- Allais, M. 1953. Le Comportement de l'Homme Rationnel devant le Risque, *Critique des Postulats et Axiomes de l'Ecole Americaine. Econometrica*, 21, 503-546.
- Barberis, Nicholas C. 2013. Thirty Years of Prospect Theory in Economics: A Review and Assessment. *Journal of Economic Perspectives*, 27, 173-96.
- Battalio, R.C., Kagel, J.H. & MacDonald, D.N. 1985. Animals' Choices over Uncertain Outcomes: Some Initial Experimental Results. *American Economic Review*, 75, 597-613.
- Bell, D.E. 1982. Regret in Decision-Making Under Uncertainty. *Operations Research*, 30, 961-981.
- Berns, G.S., Capra, C.M., Chappelow, J., Moore, S. & Noussair, C. 2008. Nonlinear Neurobiological Probability Weighting Functions for Aversive Outcomes. *NeuroImage*, 39, 2047-2057.
- Birnbaum, M.H., Patton, J.N. & Lott, M.K. 1999. Evidence against Rank-Dependent Utility Theories: Tests of Cumulative Independence, Interval Independence, Stochastic Dominance and Transitivity. *Organisational Behaviour and Human Decision Processes*, 77, 44-83.
- Bosch-Doménech, A. & Silvestre, J. 2006. Reflections on Gains and Losses: A 2×2×7 Experiment. *Journal of Risk and Uncertainty*, 33, 217-235.
- Bruhin, A., Fehr-Duda, H. & Epper, T. 2010. Risk and Rationality: Uncovering Heterogeneity in Probability Distortion. *Econometrica*, 78, 1375-1412.
- Caruso, R. & Schneider, F. 2013. Brutality of Jihadist Terrorism: A Contest Theory Perspective and Empirical Evidence for the Period 2002 to 2010. *Journal of Policy Modeling*, 35, 685-696.
- Camerer, C.F. & Ho, T.H. 1994. Violations of the Between-ness Axiom and Non-Linearity in Probability. *Journal of Risk and Uncertainty*, 8, 167-196.
- Das, S., Markowitz, H., Scheid, J. & Statman, M. 2010. Portfolio Optimisation With Mental Accounts. *Journal of Financial and Quantitative Analysis*, 45, 311-334.
- Diecidue, E. & van de Ven, J. 2008. Aspiration Level, Probability of Success and Failure and Expected Utility. *International Economic Review* 49, 683-700.
- Ellsberg, D. 1954. Classic and Current Notions of Measurable Utility. *Economic Journal*, 64, 528-556.
- Ellsberg, D. 1961. Risk, Ambiguity and the Savage Axioms. *Quarterly Journal of Economics*, 75, 643-669.
- Enders, W. & Sandler, T. 2002. Patterns of Transnational Terrorism, 1970-1999: Alternative Time-Series Estimates. *International Studies Quarterly*, 46, 145-165.
- Fishburn, P.C. 1989. Retrospective on the Utility Theory of von Neumann & Morgenstern. *Journal of Risk and Uncertainty*, 2, 127-158.
- Frey, B. & Luechinger, S. 2003. How to Fight Terrorism: Alternatives to Deterrence. *Defence and Peace Economics*, 14, 237-249.
- Gonzalez, R. & Wu, G. 1999. On the Shape of the Probability Weighting Function. *Cognitive Psychology*, 38, 129-166.
- Hadar, J. and Russell, W.R., 1969. Rules for Ordering Uncertain Prospects, *American Economic Review*, 59, pp.25-34.
- Hanoch, G. and Levy, H., 1969. The Efficiency Analysis of Choices Involving Risk, *Review of Economic Studies*, 36, pp.335-346.
- He, X.D. & Zhou, X.Y. 2013. Hope, Fear and Aspirations. *Mathematical Finance*, 26, 3-50.
- Kahneman, D. & Tversky, A. 1979. Prospect Theory: An Analysis of Decision Under Risk. *Econometrica* 47, 263-292.
- Kataoka, S. 1963. A Stochastic Programming Model. *Econometrica*, 31, 181-196.
- Kolmogorov, A.N. 1933. *Grundbegriffe der Wahrscheinlichkeitsrechnung*. Springer, Berlin.

- Landes, W. 1978. An Economic Study of U.S. Aircraft Hijacking: 1961 to 1976. *Journal of Law and Economics*, 21, 1-31.
- Levy, H., 1992. Stochastic Dominance and Expected Utility: Survey and Analysis, *Management Science*, 38, pp.555-593.
- Loomes, G. & Sugden, R. 1982. Regret Theory: An Alternative Theory of Rational Choice Under Uncertainty. *Economic Journal*, 92, 805-824.
- Lopes, L.L. 1987. Between Hope and Fear: The Psychology of Risk. *Advances in Experimental Social Psychology*, 20, 255-295.
- Lopes, L.L. 1995. An Information Processing Perspective on Choice. In *Decision Making From a Cognitive Perspective*. Edited by Douglas Medin, Jerome Busemeyer & Reid Hastie, Academic Press, San Diego, California.
- Lopes, L.L. 2013. Goals and the Organisation of Choice Under Risk. Working Paper, University of Iowa.
- Lopes, L.L. & Oden, G.C. 1999. The Role of Aspiration Level in Risky Choice: A Comparison of Cumulative Prospect Theory and SP/A Theory. *Journal of Mathematical Psychology*, 43, 286-313.
- Machina, M.J. 1982. Expected Utility Analysis Without the Independence Axiom. *Econometrica*, 50, 277-323.
- Machina, M.J. 1987. Choice Under Uncertainty: Problems Solved and Unsolved. *Journal of Economic Perspectives*, 1, 121-154.
- Markowitz, H.M. 1952. Portfolio Selection. *Journal of Finance*, 77-91.
- Meyer, J., 1977a. Further Application of Stochastic Dominance to Mutual Fund Performance, *Journal of Financial and Quantitative Analysis*, 12, pp.235-242.
- Meyer, J., 1977b. Choice Among Distributions, *Journal of Economic Theory*, 14, pp.326-336.
- Neumann, J. von & Morgenstern, O. 1947. *Theory of Games and Economic Behaviour*, Princeton University Press, Princeton, NJ.
- Phillips, P.J. 2009. Applying Modern Portfolio Theory to the Analysis of Terrorism: Computing the set of Attack Method Combinations from which the Rational Terrorist Group will Choose in Order to Maximise Injuries and Fatalities. *Defence and Peace Economics*, 20, 193-213.
- Phillips, P.J. 2013. In Pursuit of the Lone Wolf Terrorist: Investigative Economics and New Horizons for the Economic Analysis of Terrorism, Nova Science, New York, New York.
- Phillips, P.J. 2016. *The Economics of Terrorism*. Taylor & Francis (Routledge), Abingdon, Oxon & New York, New York.
- Phillips, P.J. & Pohl, G. 2014. Prospect Theory and Terrorist Choice. *Journal of Applied Economics*, 17, 139-160.
- Phillips, P.J. & Pohl, G. 2017. Terrorist Choice: A Stochastic Dominance and Prospect Theory Analysis. *Defence and Peace Economics* 28, 150-164.
- Pohl, G. 2015. Media and Terrorist Choice: A Risk-Reward Analysis. *Journal of Applied Security Research*, 10, 60-76.
- Pohl, G. 2017. Terrorist Choice and the Media. PhD Dissertation, University of Southern Queensland, Unpublished.
- Prelec, D. 1998. The Probability Weighting Function. *Econometrica*, 66, 497-527.
- Quiggin, J. 1982. A Theory of Anticipated Utility. *Journal of Economic Behaviour and Organisation*, 3, 323-343.
- Rieger, M.O. 2010. SP/A and CPT: A Reconciliation of Two Behavioural Decision Theories. *Economics Letters*, 108, 327-329.
- Rothschild, M. and Stiglitz, J.E., 1970. Increasing Risk: I. A Definition, *Journal of Economic Theory*, 2, pp.225-243.
- Rothschild, M. and Stiglitz, J.E., 1971. Increasing Risk: II. Its Economic Consequences, *Journal of Economic Theory*, 3, pp.66-84.
- Roy, A.D. 1952. Safety First and the Holding of Assets. *Econometrica*, 20, 431-449.
- Sandler, T., Tschirhart, J.T. & Cauley, J. 1983. A Theoretical Analysis of Transnational Terrorism. *American Political Science Review*, 77, 36-54.
- Schmeidler, D. 1989. Subjective Probability and Expected Utility Without Additivity. *Econometrica*, 57, 571-587.
- Shefrin, H. & Statman, M. 2000. Behavioural Portfolio Theory. *Journal of Financial and Quantitative Analysis*, 35, 127-151.
- Starmer, C. 2000. Developments in Non-Expected Utility Theory: The Hunt for a Descriptive Theory of Choice Under Risk. *Journal of Economic Literature*, 38, 332-382.
- Telser, L. 1956. Safety First and Hedging. *Review of Economic Studies*, 23, 1-16.
- Tversky, A. & Kahneman, D. 1992. Advances in Prospect Theory: Cumulative Representation of Uncertainty. *Journal of Risk and Uncertainty*, 5, 297-323.
- Wu, G. & Gonzalez, R. 1996. Curvature of the Probability Weighting Function. *Management Science*, 42, 1676-1690.
- Yaari, M.E. 1987. The Dual Theory of Choice Under Risk. *Econometrica*, 55, 95-115.