Bauer, Rotte:

Prospect Theory Goes to War: Loss-Aversion and the Duration of Military Combat

Sonderforschungsbereich 386, Paper 97 (1997)

PROSPECT THEORY GOES TO WAR: LOSS-AVERSION AND THE DURATION OF MILITARY COMBAT*

Thomas Bauer
SELAPO, University of Munich,
Rutgers University, New Brunswick,
and CEPR, London

and

Ralph Rotte
SELAPO, University of Munich,
Institute for International Relations, University of the Federal Armed Forces, Munich,
and CEPR, London

October 1997

Abstract

This paper contributes to the empirical foundation of prospect theory in real-life international relations by testing two of its major implications in the field of military conflict. Using duration analysis for a data set of twentieth century battles, it is shown how the experience of losses contributes *positively* to the preparedness to continue fighting, up to a point where casualties clearly outweigh any direct utility drawn from ordinary expected-utility theory. Moreover, the empirical results also indicate that the relative position compared to the opponent's is clearly less important for the decision whether to stop a battle or not than the change of one's own position compared to the beginning of the fight.

Correspondence to:

Ralph Rotte
SELAPO, University of Munich
Ludwigstr. 28/RG
80539 München
Germany
email: Ralph.rotte@selapo.vwl.uni-muenchen.de

Thomas Bauer
Economics Department
Rutgers University
New Jersey Hall
75 Hamilton Street
New Brunswick, NJ 08903-5055, USA
email: Bauer@fas-econ.rutgers.edu

**: We would like to thank Allan C. Stam and Robert L. Helmbold for providing the data for this paper, and Jurgen Brauer, Ira N. Gang, Chemi Gotlibovski, Christoph M. Schmidt, and Ulrich Vogel for helpful comments and suggestions.*

1. Introduction

Since its first formal formulation by Kahnemann and Tversky (1979), prospect theory has been frequently used as an alternative for traditional expected-utility approaches to individual decision-making in the social sciences. In recent years it has also become one of the most intensively discussed topics in international relations, and especially in foreign policy theory. In particular it has been the special implications for risk-aversion and risk-acceptance in international conflict which have attracted the attention of applied political scientists and international political economists. Nevertheless, prospect theory suffers from a number of shortages which mainly result from its roots in experimental psychology. Levy (1997) has given a comprehensive overview of the methodological problems international relations scholars get involved in when using the results of prospect theory for analyzing actual political behaviour in the international sphere: On the one hand, generalizing from experimental results implies questions of external validity, since in most cases, international relations has to deal with states and collective political units instead of individuals, which results e.g. in problems of aggregation and group dynamics. On the other hand, experimental results lack the framework of real-life decision-making under risk, which may basically change the whole attitude of test persons to the choices they are meant to take seriously. Despite valuable case studies by e.g. Farnham (1992), McDermott (1992), McInerney (1992), Richardson (1992) or Weyland (1996), the core problem of applying prospect theory in international relations so far has been a lack of broader empirical evidence in real-life settings.

This paper tries to contribute to such an empirical foundation of prospect theory in real-life, i.e. historical decision situations by testing two of its major implications in the field of military conflict. In brief, by using duration analysis for a data set of twentieth century battles, we show how the experience of losses contributes *positively* to the resolution to continue fighting, up to a point where casualties clearly outweigh any direct utility drawn from ordinary expected-utility theory. Moreover, our empirical results also indicate that the impact of the relative position vis-à-vis one's opponent is clearly lower when it comes to deciding whether to continue a battle or not, than the change of one's own position at the beginning of the fight. We take both results as indices for the *risk orientation* and *reference dependence* hypotheses which are important characteristics of prospect theory.

The paper is organized as follows: Section 2 gives a short overview of the main features of prospect theory and their implications for international relations in general, and for situations of international disputes in particular. Focussing on the basic elements of war according to Clausewitz (1832), we then formulate some basic hypotheses concerning military decision-makers in the case of battle in section 3. Sections 4 explains the dataset and the statistical method we use for testing our hypotheses. Section 5 presents our estimation results. Section 6 concludes.

2. Prospect Theory and International Conflict

The concept and experimental foundations of prospect theory have been summarized extensively in Kahnemann and Tversky (1979), Quattrone and Tversky (1988), Levy (1992a, 1992b, 1997) or Shafir (1992). It is therefore sufficient for our purposes to hint only at the main ideas of prospect theory and their fundamental implications for international relations. Basically, contrary to traditional expected-utility theory, prospect theory provides the analytical framework for decisions under risk with a non-linear utility function where people's decision-making varies depending on the expectation of losses or gains, and on the change of likely outcomes compared with a principally preferred status quo reference point. Thus, while the standard utility function is defined on final asset positions, utility in prospect theory always refers to the change of wealth resulting from a choice (*reference dependence*). Moreover, while the standard utility function is assumed to be concave for wealth, implying diminishing returns of increasing wealth, prospect theory assumes an S-shaped function for changes in wealth, where the value function is concave for gains, and convex as well as steeper for losses, relative to the neutral reference point. This results in the disutility of losing an item being greater than the utility of acquiring the same item (*endowment effect*).

A resulting specialty of this utility concept is its implications for *risk attitudes*. While traditional utility theory assumes risk aversion independent from a reference point, prospect theory predicts risk aversion for gains and risk seeking for losses. This means that potential gains are undervalued in the decision-maker's calculation, while losses are overvalued relative to the reference point. Moreover, prospect theory predicts that in a dynamic context with subsequent decisions, people will adjust rapidly to new situations in the domain of gains, whereas the original status quo tends to stay the reference point in the domain of losses. This means that improvements of one's situation are accepted quickly as a new reference point for further decisions, while adjustments of one's reference point take extremely long times in case of deterioration, thus even fostering risk seeking when subsequent losses are experienced. Thaler (1980) has explained the latter point with an example which has also been used as an illustration by Kahnemann and Tversky (1983): A man develops a tennis elbow just after having paid his membership fee in a tennis club. Perceiving the fee as a cost, and not using the resulting right to use the club's facilities as a loss, leads him to continue to play despite increasing agony in order to avoid wasting his investment. Another illustration would be an investor throwing good money after bad in the hope to make up for recent losses in a project which has proved to be a failure (Jervis 1992).

This paper does not aim at contributing to the discussion among political scientists, psychologists and economists whether prospect theory is really a theoretical alternative to the concept of standard utility-maximation if one takes into account the possibilty of a more general formal model of rational decision-making (Machina 1987, Levy 1997). We rather rely on the outcomes of prospect theory which result in a number of important consequences for decision-makers' behaviour in international relations, which, from a traditional rational choice point of view are hard to incorporate in a framework of economic optimality. Levy (1992) and Jervis (1992) have summed up the political implications of prospect theory. First, there is a general tendency for non-aggressive behaviour of states due to preference of the current status quo system. For the Soviet Union in the Cold War system, for example, prospect theory implies that the Soviet aim of consolidating power in the East European countries was more important than expanding the Soviet Block, e.g. in Africa or Latin America. This stabilization effect of the prospect theory perspective of international relations is increased by military deterrence as long the defensive character of national deterrence power is explicit and undoubted for the potential adversaries.

On the other hand, prospect theory also implies several destabilizing consequences for the international system when it comes to perceived losses. If a country expects a deterioration of its international standing it can be expected to take risky and even aggressive actions in order to prevent that deterioration. Again, in the case of the Soviet Union, prospect theory gives a good explanation for the preparedness to use massive military force within the Warsaw Pact against Hungary in 1956 or Czechoslovakia in 1968, as well as for the invasion of Afghanistan in 1979. In each case, the Soviet sphere of influence was perceived as being endangered either by expansion of anti-communist democracy into Eastern Europe or by Islamic fundamentalism spreading throughout Central Asia. Offensive political and military action may thus be rooted in a basically defensive framework of perception. At the same time, since prospect theory in principle deals with individuals, it also gives an explanation for aggressive foreign policy being used as diversion from a country's internal problems by politicians who want to preserve their endangered position in the political system.

Loss-aversion of decision-makers has also important consequences for the settlement of international disputes and for the duration of actual international conflicts. Since potential losses are valued higher than respective gains, international negotiations may be easier in case of distribution of gains than of losses (Stein 1992). It seems therefore logical that international cooperation and regimes should develop slower and less smooth when it comes to redistribution of limited resources, like e.g. water in the Middle East, or even to the division of costs, like in environmental protection and climate change. Concerning the effect of loss-aversion and risk seeking in actual international conflicts, prospect theory predicts that wars, just like futile policies, should take longer to stop than ordinary cost-benefit calculation would imply. As soon as losses have occured and original strategic plans have failed, decision-makers do not adjust their expectations and their reference point to the new situation but keep on engaging their nations' resources in the attempt to nevertheless justify the losses by success (Levy 1996). The result is a prolongation of wars which is irrational since wasteful from an economic perspective. Afghanistan, Vietnam and especially the Great War are striking examples for this consequence. It is this behaviour of being influenced by sunk costs in subsequent decision-making which is crucial for our empirical approach to prospect theory.

3. Resulting Hypotheses on Combat Duration

We want to test the implications of prospect theory for international conflicts by analyzing a data set on battles provided by Helmbold (1991). Following Clausewitz (1832) we interpret battles as separate acts which together constitute a war. The data set then enables us to test the results of prospect theory in the following framework: Given the initial decision to start an offensive against an opponent, the politico-military leadership of the attacking side find themselves in the situation of whether to continue the offensive or to stop the attack. It is of course crucial to control for the outcome of the battle. Given that one takes into account that the duration of military combat will depend on whether one side wins or loses, the decision to continue an attack will depend on a number of determinants including capabilities, numbers, and losses suffered. In our view, the peculiarities of this situation of military decision-making are very valuable in assessing empirically the predictions of prospect theory in real-life international relations. First, in most situation of modern warfare, the decisions of military leaders will be influenced by political considerations and be taken in an environment of group interaction in the general staff. Contrary to typical psychological experiments, one can therefore test the implications of individual-based prospect theory in a social group context. Second, singular battles as basic elements of war, provide a framework of decision-making whose complexity is as limited as possible in international relations. Although decisions in military combat are taken in a strategic environment including interaction with the enemy, their basic structure is more straightforward than for example decision-making about a war itself. Finally, having in mind Clausewitz' "economics of forces", if one takes military thinking as a special way of economic rationality, empirical evidence for the implications of prospect theory in the situation of military combat would be an important indication of the limited scope of standard utility theory in international relations.

Based on the short outline of the basics of prospect theory we can formulate two important hypotheses about the behaviour of decision-makers in deciding about continuing or stopping an offensively led battle.

Hypothesis 1: *The experience of increasing losses subsequently decreases an attacker's willingness to stop a battle.*

This hypothesis results directly from the loss aversion and risk affinity predicted by prospect theory. Just like political leaders are prepared to continue a war in order to make up for previous failures, military decision-makers will be prepared to continue fighting if their forces have suffered serious losses, since their reference point remains the situation at the battle's start. The best example is provided by the experiences of the Western Front during the Great War, where German and French losses amounted for more than 670,000 and 850,000, respectively, from August to November 1914 alone, exceeding clearly any subsequent casualties in a similarly short period of time during the war (Woytinsky 1928). Of course, one cannot take a linear influence of losses on the duration of combat for granted. Even in Vietnam or Afghanistan, political leaders experienced a maximum threshold of losses which forced them to give up fighting after a certain though long period of time. It is decisive for assessing the implications of prospect theory when this point is reached. Prospect theory predicts that leaders, due to their loss-aversion should be prepared to accept an extremely high rate of casualties before becoming increasingly prepared to stop an offensive. One has therefore to take account of potential non-linearity in the influence of casualties on the willingness to keep on fighting.

Hypothesis 2: *When deciding about continuing an offensive, leaders will put more weight in their own side's losses than in those suffered by the defender.*

It seems obvious from prospect theory that a decision-maker of the attacking side will overvalue his own losses compared to his gains. Gains in this setting may be interpreted as the defender's losses, since the major aim of an offensive is typically to neutralize the enemy's forces (Clausewitz 1832). From experimental evidence we expect the impact of own losses on the decision of whether to continue or to stop a battle at least twice as high than the defender's (Levy 1992).

These two hypotheses cover the main results of prospect theory for international conflicts, the *risk orientation* and the *reference dependence* implications as outlined above. However, there are several additional hypotheses, apart from the success or failure of an offensive, which cover necessary controls in modelling a military leader's decision to continue or to cease the attack. These hypotheses mainly result from the experience of military history, as summarized in e.g. Keegan (1994). Again, it is important to remember that those hypotheses do not depend on the effect of the variables on the outcome of a battle but only on the leaders preparedness to keep on fighting, independently of his prospect of victory.

Hypothesis 3: *The greater total available manpower, the more will the attacker be prepared to continue the battle.*

This hypothesis results from the simple experience that larger armies provide the foundation for longer battles because of the improved availability of reserves. This is one principal result of mass mobilization since the 19th century (Townsend 1997). A leader who can rely on massive reserves will choose prolonged fighting more easily even when success is not immediately at hand.

Hypothesis 4: *The greater the logistic, technical and information advantage of the attacker the more will he be prepared to continue the battle.*

Taking account of the important role of military technology and supplies in modern warfare, the willingness to continue an offensive will be greater if one's own forces are clearly superior, as far as material supplies and intelligence are concerned. A strong position of the defender, e.g. fortifications or trench systems like in the Great War, however, will decrease those advantages and is therefore expected to increase the willingness to stop an attack.

Hypothesis 5: *Given the basic decision to start an offensive, the better the morale and the training of his forces the more will the attacker be prepared to stop the battle.*

This hypothesis seems counterintuitive at first sight since one could expect morale and training of the available manpower to be essential elements for keeping up an offensive. As Clausewitz (1832) or Parker (1993) have pointed out, however, both are even more important in case of a retreat. This means that the spirit and discipline of one's troops are especially important in case of stopping an offensive, which is why a leader with badly trained and badly motivated troops will be inclined to hold up the attack since he has to fear the complete dissolution of his army when calling for retreat. Given the initial decision to start an offensive, good morale and training, on the other hand, enable a military leader to choose the option of stopping the attack easier, because he does not have to expect problems with his troops' discipline.

Hypothesis 6: *Leaders of coalition forces are less prepared to stop an offensive.*

First, leaders of coalition armies find themselves even more under the political pressure to be successful, since they are basically responsible to more than one government. Their loss-aversion is therefore further increased. Moreover, losses might be perceived to be lower by the leader in case of a multinational force than in case of an army solely consisting of own national troops. The Allies' problems in coordinating their efforts in the World Wars, e.g. during the German spring offensives of 1918, can be partly attributed to this attitude of intending to safe own troops and to deploy one's allies' forces instead (Miquel 1983).

Hypothesis 7: *Leaders in the two World Wars will be more prepared to accept higher losses and thus continue a battle.*

This final hypothesis is rooted in two specialties of the military and political attitudes of the opponents in the World Wars. First, in the Great War, it was military doctrines of offensive and later of attrition which made military leaders expect high casualties and get used to them (Storz 1992). Stam (1996) gives a critical discussion of this "cult of the offensive" argument. Second, for the Second World War, one has to take account of the ideological character of the war, especially on the Eastern front (Townsend 1997), which led to a high degree of fanatism and, consequently, to a lower preparedness to stop attacks against the enemy.

4. Data Set and Methodology

A proportional hazard model is used to test the hypotheses outlined in the last section. This model, which has been developed by Cox (1972)[1], is a method of analyzing the effects of covariates on the hazard rate, $\lambda(t)$. Recent applications of this kind of duration analysis in the field of international conflicts include Vuchinich and Teachman (1993), Bueno de Mesquita and Siverson (1995), Stam (1996), and Bennett and Stam (1996). Formally, the hazard rate is defined as

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{P(t \le T < t + \Delta t | T \ge t)}{\Delta t} , \qquad (1)$$

where t denotes observed duration times, which are drawn from a random variable T. This definition shows that the hazard rate is the probability that an event will end in the short interval of length Δt after t, given that the event has lastet until t. In order to analyze the effect of covariates on the hazard rate, the proportional hazard model specifies that

[1] A basic introduction to the analysis of duration models is given by Kiefer (1988). More comprehensive sources of duration models can be found in Kalbfleisch and Prentice (1980) and Lancaster (1990).

$$\lambda(t_i) = \lambda_0(t_i)\, e^{X'\beta} , \tag{2}$$

where i is an index over the ordered failure times t_i, X is a vector of covariates and β a parameter vector which has to be estimated; $\lambda_0(t_i)$ is the baseline hazard rate at time t for the covariate vector 0. The covariates may increase or decrease the hazard rate relative to the baseline hazard by shifting it proportionately for that duration. In principle, the baseline hazard is a parameter for each observation which must be estimated. However, Cox's partial likelihood estimator provides a method of estimating β without estimation of λ_0. The main idea behind this estimator is to obtain informations about the unknown coefficients β from the order of the observed durations without specifying the baseline hazard λ_0. Consider the set of observations R_i that are at risk at time t_i. Assuming that there are no censored observations, the conditional probability that observation i fails at t_i given that any of the observations in R_i could have been concluded at t_i is

$$\frac{\lambda(t_i;X_i)}{\sum_{j \in R_i}^{n} \lambda(t_i;X_j)} = \frac{e^{X_i'\beta}}{\sum_{j \in R_i}^{n} e^{X_j'\beta}} , \tag{3}$$

where n is the total number of observations. Taking the product over all failure points t_i of (3) and taking logarithms gives the partial log-likelihood function for estimating the parameters β (Kalbfleisch and Prentice 1980; Kiefer 1988):

$$\ln L = \sum_{i=1}^{n} \left\{ X'\beta - \ln\left(\sum_{j \in R_i}^{n} e^{X'\beta} \right) \right\} . \tag{4}$$

In our case, the proportional hazard model is applied to a data set of the U.S. Army Concepts Analysis Agency (Helmbold 1991) available via internet, which provides detailed information on the characteristics of 660 battles which occured in the period between 1620 and 1982, covering major international conflicts from the Thirty Years' War to the Israeli Operation "Peace in Galilee". The special advantage of this data set for our empirical problem is its information on offensive operations which enable us to consider the duration of a battle as the result of the attacking side's leaders' decisions only, since the defender's behaviour is basically excluded by defining a counter-attack as a new battle. The construction of the data set allows us to treat each observation as a separate event with a limited operational goal. For example, the battles of the Marne in September 1914 and of Kursk in July 1943, are split into 8 and 7 distinct operations (battles), respectively.

In order to obtain a relatively homogeneous sample on modern warfare we restrict our analysis to observations in the 20th century. Furthermore, we dropped all observations where the attacker's total personnel strength is below 10,000 soldiers. The major reason for this is the oversampling of smaller tactical operations involving US forces in the two World Wars. Not taking into account all observations with missing values in one of the used variables, a final sample of 301 observations remains for the empirical analysis. The definition of the variables as well as descriptive statistics are given in Table 1.

As endogenous variable we use the total length of combat in days (DAYS). This variable was constructed from the dates of the battles given in the dataset. Table 1 shows that in the period under study battles lasted on average 5 days. Figure 1 shows the empirical hazard function which has been obtained using the Kaplan-Meier product-limit method.[2] The figure reveals that

[2] See Kalbfleisch and Prentice (1980) and Cox and Oakes (1984) for a thorough discussion of the product-limit estimator.

the hazard function has a peak within the first three days. Declining thereafter, the hazard rate remains relatively stable at about 10 percent with small peaks after 8, 15 and 24 days. After 25 days the hazard rate increases very sharply.

To test the prospect theory implications in our model we use different measures of the casualties of the parties involved in the battle. First, we use the attacker's and defender's casualties standardized by the attacker's and defender's total personnel strength (CASUALA and CASUALD), respectively, and the square of these variables to allow for a possible nonlinear relationship between casualties and the length of combat. Second, we include the ratio of the attacker's relative casualties and the defender's relative casualties (CASRATIO) in order to control for the seriousness of the attacker's casualties compared to the defender's.

Figure 2 reveals that the empirical hazard rates depict very different patterns for different casuality rates of the attacker. For casuality rates of less than 30% the patterns are quite similar to the hazard rate in Figure 1. According to Figure 2 there is a tendency that the first peak in the hazard rates occurs the later the higher the relative losses of the attacker. This observation speaks in favour of prospect theory. For casualties of more than 30% the hazard rate increases steadily up to a length of 22 days. After 15 days the probability of stopping combat increases nonlinearly with the casuality rate being highest for relative losses of less than 10%, followed by relative losses between 20% and 30%, and casuality rates over 30%. The lowest probability of stopping an offensive after 20 days appear to be at casuality rates between 10% and 20%.

Apart from the described measures for casualties, we control for the absolute personnel strength of the attacker (FORCEA) and the defender (FORCED), respectively, as well as the relative personnel strength of the attacker compared to the defender (FRATIO). Furthermore, we consider variables which indicate the attacker's relative advantage in combat effectiveness (CEA), leadership (LEADA), logistics (LOGSA), intelligence (INTELA), and technology

(TECHA). As outlined above, we expect that a relative advantage of the attacker in these variables should have a negative influence on the hazard and therefore result in longer battle duration, given a control for the battle's outcome. In order to provide the latter, we consider two dummy variables which indicate whether the attacker wins the battle (WINA) or whether there is a draw (WINN) with the defender being the winner as reference group. It is important to keep these two control variables in mind when interpreting the empirical results of our analysis which does *not* provide information about the determinants of *winning* a battle but about the determinants of its duration *given its outcome*. Training (TRNGA) and morale (MORALA) are expected to increase the hazard, i.e. the leader's willingness to stop the fight.

Additional variables include a dummy variable which indicates whether the attacking army consists of coalition forces (COALI), a dummy variable indicating a well-established position of the defender (POST), and finally two dummy variables indicating whether the battle occurs during World War I (WW1) or World War II (WW2). It is hypothesized that a battle will last longer if the army consists of coalition forces, while a well-established position of the defender should increase the hazard. Battles during the World Wars are expected to last longer due to their special strategic and ideological characteristics.

5. Estimation Results

Table 2 presents the results of three different specifications of the hazard analysis. The first column of Table 2 shows the estimates obtained without considering the relative casualties of the defender and the dummy variables for the two World Wars. In the second column we add the two World War dummies and in the third we further consider the impact of the defender's casualties. The log-likelihood ratio tests reported at the bottom of Table 2 show that the hypothesis that all coefficients are zero could be rejected on the 1% value for all three specifications. The log-likelihood values further reveal that the inclusion of the two World War dummies in the second specification and the measures of the defender casualties in the third specification significantly increase the explanatory power of the regression without having remarkable effects on the rest of the coefficients.

Let us first compare the estimated results for our control variables to our expectations according to Hypotheses 3 to 7. The estimated coefficients show that FORCEA has a small but significant negative effect on the hazard rate holding constant all other variables, whereas FORCED and FRATIO have no significant effect. This result is in line with Hypothesis 3, since it means that the bigger the attacker's reserves, the longer the combat can be endured. It also confirms the result of Bennett and Stam (1996) on the micro-level of warfare, who found a positive effect of total military personnel on interstate wars.

From the various variables measuring the attacker's relative advantage only TRNGA and MORALA have a significant effect on the probability to stop a battle. The estimated positive coefficients imply that the survival time of combat decreases with the training and moral advantage of the attacker. This is consistent with Hypothesis 5. It is interesting, however, that the technical advantage has no significant effect on combat duration if one controls for the two World Wars and for the casualties of the defender. Moreover, a well-established position of the defender has no significant influence on combat duration. The insignificance of material and information advantages thus cast important doubts on Hypothesis 4. The same holds for Hypothesis 6, since COALI remains clearly insignificant throughout the estimations. Finally, Hypothesis 7 can be accepted only for World War II. The dummy for WW II is significantly negative, indicating that in battles between 1939 and 1945, the willingness to back down from an attack was smaller than in other wars. Somewhat surprisingly, World War I which is known for its long futile offensives in trench warfare, does not show a significant similar pattern.

Coming to the two crucial control variables in our empirical setup, i.e. those for the outcome of a battle, compared to the situation where the attacker or the defender wins, the duration of combat will be shorter if it ends with a draw. This implies that leaders recognize very fast if neither of the two armys has a chance to win. It is interesting, however, that there seems to be no difference between an attacker's ultimate failure or success in battle.

Turning to the most important variables, Table 2 shows that there is an U-shaped relationship between the attacker's relative casualties and the battle hazard, or, in other words, that there is an inverted U-shaped relationship concerning survival time. However, the overall effect of the relative casualties of the attacker on the the duration hazard is always negative implying an increasing survival time of a battle with increasing losses. Taking the respective coefficients of the third specification one can calculate that the negative effect of CASUALA is increasing up to a rate of 61%, decreasing again thereafter. In other words, a military leader facing the decision to stop a battle or not will be increasingly willing to continue fighting with casualties rising to three fifths of his available forces before changing his mind in favour for ceasing the attack. Given that the attacker's average casualty rate in our data set is 8 per cent, this means that in most cases, increasing losses will make the leaders fight a battle through till the end. Hypothesis 1 can therefore be not refused, which gives a clear confirmation of the implications of prospect theory for our data set.

The coefficients in the third specification show a similar but weaker pattern for the relative casualties of the defender. Interpreting the coefficients of the casualty variables as weights which are attributed to one's own and the enemy's losses in decision-making about continuing a battle, thus reveals that the attacker values his own losses about three times as high as his gains, i.e. the defender's losses. This is a rate which is even higher than the experimental ratio of 2:1 and perfectly in line with Hypothesis 2. Finally, the significant positive coefficient on the ratio of the relative casualties of the attacker and the defender imply that the higher the relative casualties of the attacker compared to the defender, the shorter is the survival time of combat.

6. Conclusion

The empirical results of a proportional hazard model show that there is a negative non-linear relationship between the relative casualties of the attacker and the probability to stop combat. We also found that total personnel strength of the attacker decreases the probability to stop a battle. Relative advantage of the attacker with regard to training and morale results in shorter battles whereas technical advantage of the attacker has no significant effect on battle duration. Finally, battles in World War II last significantly longer.

Basically, our duration analysis reveals that a leader's willingness to stop an offensive will decrease with increasing losses up to an extremely high own casualty rate of more than 60% while the attacker's losses are overvalued compared to the defender's by about 3:1 in the decision-making process. These results are in strong favour of the implications of prospect theory and provide some non-experimental empirical evidence for the theory's value in actual international conflict situations. Although it remains a difficult task to provide further evidence for testing the prospect theory model against standard utility maximization models, the findings of this paper hint at some strong empirical foundation of prospect theory which therefore has to be taken serious as an explanatory tool for decision-makers' behaviour in international relations.

References

Bennett, D. S., and A. C Stam III (1996): "The Duration of Interstate Wars, 1816-1985," *American Political Science Review*, **90**, 239-257.

Bueno de Mesquita, B., and R. M. Siverson (1995): "War and the Survival of Political Leaders: A Comparative Study of Regime Types and Political Account Ability," *American Political Science Review*, **89**, 841-855

Clausewitz, C. v. (1990 [1832]): *Vom Kriege*. Berlin: Ullstein

Cox, D. R. (1972): "Regression Models and Life Tables," *Journal of the Royal Statistical Society*, Series B, **34**, 187-220.

Cox, D. R., and D. Oakes (1984): *Analysis of Survival Data*. London: Chapman & Hall.

Farnham, B. (1992): "Roosevelt and the Munich Crisis: Insights from Prospect Theory," *Political Psychology*, **13**, 205-235.

Helmbold, R. L. (1991): Combat Effectiveness Data Set, US Army Concepts Analysis Agency, available via internet from A. C. Stam, *http://www.yale.edu/plsc151a/*

Jervis, R. (1992): "Political Implications of Loss Aversion," *Political Psychology*, **13**, 187-204.

Kahnemann, D., and A. Tversky (1979): "Prospect Theory: An Analysis of Decision under Risk," *Econometrica*, **47**, 263-291.

Kahnemann, D., and A. Tversky (1984): "Choices, Values, and Frames," *American Psychologist*, **39**, 341-350.

Kalbfleisch, J. D., and R. L. Prentice (1980): *The Statistical Analysis of Failure Time Data*. New York: John Wiley & Sons.

Keegan, J. (1994): *A History of Warfare*. London: Randomhouse

Kiefer, N. M. (1988): "Economic Duration Data and Hazard Functions," *Journal of Economic Literature*, **26**, 646-679.

Lancaster, T. (1990): *The Econometric Analysis of Transition Data*. Cambridge: Cambridge University Press.

Levy, J. S. (1992a): "An Introduction to Prospect Theory," *Political Psychology*, **13**, 171-186.

Levy, J. S. (1992b): "Prospect Theory and International Relations: Theoretical Applications and Analytical Problems," *Political Psychology*, **13**, 283-310.

Levy, J. S. (1996): “Loss Aversion, Framing, and Bargaining: The Implications of Prospect Theory for International Conflict,” *International Political Science Review*, **17**, 179-195.

Levy, J. S. (1997): “Prospect Theory, Rational Choice, and International Relations,” *International Studies Quarterly*, **41**, 87-112

Machina, M. J. (1987): “Choice Under Uncertainty: Problems Solved and Unsolved,” *Journal of Economic Perspectives*, **1**, 121-154.

McDermott, R. (1992): “The Failed Rescue Mission in Iran: An Application of Prospect Theory,” *Political Psychology*, **13**, 237-264.

McInerney, A. (1992): “Prospect Theory and Soviet Policy Towards Syria, 1966-1967,” *Political Psychology*, **13**, 265-282.

Miquel, P. (1983): *La Grande Guerre*. Paris: Fayard

Parker, G. (1995): "The Western Way of War," in: G. Parker (ed.), *The Cambridge Illustrated History of Warfare: The Triumph of the West.* London, New York: BCA

Quattrone, G. A., and A. Tversky (1988): “Contrasting Rational and Psychological Analyses of Political Choice,” *American Political Science Review*, **82**, 719-736.

Richardson, L. (1992): “Avoiding and Incurring Losses: Decision-making in the Suez Crisis,” *International Journal*, **47**, 370-401.

Shafir, E. (1992): “Prospect Theory and Political Analysis: A Psychological Perspective,” *Political Psychology*, **13**, 311-322.

Stam, A. C. (1996): *Win Lose or Draw. Domestic Politics and the Crucible of War.* Ann Arbor: University of Michigan Press.

Stein, J. G. (1992): “International Cooperation and Loss Avoidance: Framing the Problem,” in: J. G. Stein and L. Pauly (eds.), *Choosing to Cooperate: How States Avoid Loss*, Baltimore: Johns Hopkins University Press.

Storz, D. (1992): *Kriegsbild und Rüstung vor 1914. Europäische Landstreitkräfte vor dem Ersten Weltkrieg.* Berlin: Mittler und Sohn.

Thaler, R. (1980): “Toward a Positive Theory of Consumer Choice,” in: *Journal of Economic Behavior and Organization*, **1**, 39-60.

Townsend, C. (1997): "Introduction: The Shape of Modern War," in: C. Townsend (ed.), *The Oxford Illustrated History of Modern War*, Oxford, New York: Oxford University Press.

Vuchinich, S., and J. Teachman (1993): "The Duration of Wars, Riots, and Family Arguments," *Journal of Conflict Resolution*, **37**, 544-568.

Weyland, K. (1996): "Risk Taking in Latin American Economic Restructuring: Lessons from Prospect Theory," *International Studies Quarterly*, **40**, 185-208.

Woytinski, W. (1928): *Die Welt in Zahlen*, vol. 7. Berlin: Rudolf Mosse Buchverlag.

Table 1: Variable Description and Descriptive Statistics*

Variable	Definition	Mean	Standard Deviation
DAYS	Total length of combat	5.196	6.452
CASUALA	Attacker's personnel battle casualties in 1.000 / FORCEA	0.081	0.101
CASUALD	Defender's personnel battle casualties in 1.000 / FORCED	0.196	0.232
CASRATIO	CASUALA / CASUALD	0.873	1.190
FORCEA	Attacker's total personnel strength in 1.000	133.787	244.698
FORCED	Defender's total personnel strength in 1.000	87.163	158.700
FRATIO	FORCEA / FORCED	2.542	1.983
CEA	Attacker's relative combat effectiveness (Ranging from -4 to +4)	0.140	0.757
LEADA	Attacker's relative leadership advantage (Ranging from -4 to +4)	0.136	0.636
TRNGA	Attacker's relative training advantage (Ranging from -4 to +4)	0.047	0.646
MORALA	Attacker's relative morale advantage (Ranging from -4 to +4)	0.289	0.616
LOGSA	Attacker's relative logistics advantage (Ranging from -4 to +4)	0.113	0.536
INTELA	Attacker's relative intelligence advantage (Ranging from -4 to +4)	0.110	0.533
TECHA	Attacker's relative technology advantage (Ranging from -4 to +4)	0.086	0.335
COALI	Dummy indicating whether the attacking army consists of coalition forces	0.020	0.140
WINA	Dummy indicating whether attacker wins battle	0.628	0.484
WINN	Dummy indicating whether battle ends with a draw	0.090	0.286
POST	Dummy indicating existence of a well-established position (fortification or entrenchment) of the defender	0.246	0.431
WW1	Dummy for World War I	0.286	0.453
WW2	Dummy for World War II	0.517	0.501

*: Source: Helmbold (1991), own calculations. Number of observations: 301.

Table 2: Estimation Results*

	(1)		(2)		(3)	
Variable	**Coefficient**	**(t-ratio)**	**Coefficient**	**(t-ratio)**	**Coefficient**	**(t-ratio)**
CASUALA	-9.538††	(-6.79)	-10.752††	(-7.08)	-8.892††	(5.27)
CASUALA^2	7.777††	(3.49)	8.720††	(3.83)	7.258††	(3.03)
CASUALD	-	-	-	-	-2.767††	(-2.35)
CASUALD^2	-	-	-	-	2.305†	(1.90)
CASRATIO	0.280††	(5.22)	0.283††	(5.32)	0.232††	(3.83)
FORCEA	-0.002††	(-2.08)	-0.002††	(-2.16)	-0.002††	(-2.32)
FORCED $\cdot 10^{-3}$	-0.260	(-0.25)	-0.270	(-0.25)	-0.165	(-0.15)
FRATIO	-0.022	(-0.61)	0.003	(0.10)	0.043	(1.11)
CEA	-0.091	(-0.64)	-0.148	(-1.03)	-0.101	(-0.71)
LEADA	-0.064	(-0.43)	-0.104	(-0.72)	-0.092	(-0.63)
TRNGA	0.394††	(2.43)	0.423††	(2.63)	0.403††	(2.52)
MORALA	0.212†	(1.82)	0.214†	(1.84)	0.213†	(1.83)
LOGSA	-0.236†	(-1.77)	-0.162	(-1.16)	-0.194	(-1.39)
INTELA	-0.087	(-0.62)	-0.078	(-0.54)	-0.047	(-0.32)
TECHA	-0.362†	(-1.77)	-0.301	(-1.46)	-0.169	(-0.76)
COALI	-0.733	(-1.55)	-0.765	(-1.60)	-0.543	(-1.14)
WINA	0.022	(0.14)	0.043	(0.27)	0.109	(0.67)
WINN	0.415†	(1.77)	0.524††	(2.20)	0.549††	(2.31)
POST	-0.044	(-0.32)	-0.095	(-0.64)	-0.094	(-0.64)
WW1	-	-	-0.120	(-0.53)	-0.040	(-0.17)
WW2	-	-	-0.575††	(-3.30)	-0.543††	(-3.09)
Log-Likelihood	-1375.88		-1369.33		-1365.74	
LRT (χ^2)	164.37		177.45		184.64	
χ^2_C	33.41		36.19		38.93	

*: Number of Observations: 301. A † denotes statistical significance at the 10%-level, a †† on the 5%-level (two-sided test). LRT(χ^2) is the likelihood-ratio test statistic on the hypotheses that all coefficients are zero. χ^2_C is the 1 percent critical value corresponding to the respective LRT(χ^2) test statistic.

Figure 1: Empirical Hazard Rate

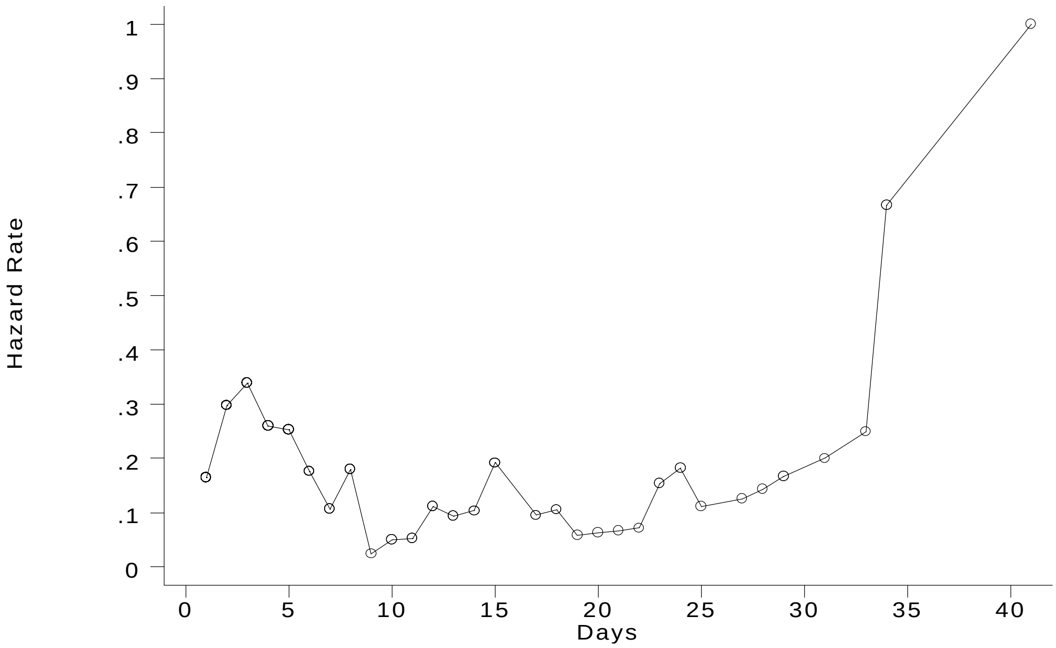

Figure 2: Empirical Hazard Rates by Casuality Rates