Historical Analysis of Conflict Termination

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Abstract

Historical Analysis of Conflict Termination is concerned with identifying the key factors driving the termination of hostilities in a set of 20th Century interstate conflicts; understanding why states surrendered during wars.

The paper is based upon an economic rational expectations model of conflict termination, where fighting stops as expected costs exceed expected benefits for all parties involved in a war. This relationship can be expressed as a set of inequalities, with variables representing a warring state's military-economic-social costs and the war aims held. The coefficients of the variables in this expression give the relative utility of different objectives and disutility of costs.

Historians collected data to quantify the actual value of these variables for a set of 20th Century conflicts. The inequalities were then solved to determine the coefficient values. These values provide a quantified indication of how hard a nation will fight in pursuit of a given set of objectives and the pressure that would be required to break its will to fight.

The paper discusses the various methods used to structure and solve the functions and comments on the application of the resultant mathematical model in the light of the emerging military concepts of Effects Based Operations.

1. Background

The vast majority of International Relations theory and conflict research has concentrated upon conflict prediction1, with a view to crisis prediction, conflict causation, and prevention. A vast (and surprisingly quantitative) literature has been assembled on this, mostly framed by the cold war context of the 1960's. However the results have often been disappointing; either "stating the obvious", or provide descriptive functions too weak to deal with a system where both false-positives and false negatives have very high ancillary costs.

In contrast, this study focused upon the end states of wars, with a view to understanding how they are won[2].The study is founded upon a "rational expectations" model of conflict, and seeks to predict the outcome of conflict on the basis of the gains and losses suffered by the parties involved.

The Historical Analysis (HA) team at Dstl specialises in drawing enduring lessons for future conflict from historical data. The emphasis is on statistical analysis of quantitative, empirical data, gathered by external historians.

2. "Rational Expectations"

"Rational-Expectations" is a theory of behaviour initially drawn from economics, though commonly encountered in several branches of OA, such as game theory. It refers to a theory of behaviour which states "actors will take choices designed to maximise their perceived payoff according to their schemes of utility[3]". This can be simply re-phrased as "people will act in what they think is their own self-interest".

In our study, rational expectations is being used to describe the actions of states rather than individuals. It is grounded in the realist paradigm of international relations. This paradigm sees states as the main actors in an anarchic international system, and stresses their fundamentally calculating and selfish nature.

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[1] See Bueno de Mesquita, "The War Trap" (Yale Uni 1983), Singer/Small "Resort to arms" (Sage Publications 1982), Brecher/Moser/ Wikenfield "Crises in the 20th century" (Pergamon 1988) for examples of the major literature in this field.

[2] A more limited and theoretical literature exists, but little empirical study. See Wittman, "How a War Ends; A Rational Model Approach" Journal of Conflict Resolution, Dec 1979.

[3] A scheme of utility is an advance on the simple utility model; it provides not only the preferences of an actor for various goods, but also their attitude to risk-taking and "endowment effect".

Insofar as it relates to war, rational expectations theory makes the following predictions;

- States become involved in wars because they expect the benefits of fighting to outweigh the costs[4].
- States will continue to fight so long as their expected benefits from fighting exceed their expected costs.
- Hence warfare will continue until all sides see it as being in their interest to stop.

Note that expected benefit exceeding expected cost here does not imply an "expected net gain" from the conflict, settlements are often merely the "least bad option" for warring parties. Further note that warfare tends to be, in economic terms, a negative sum game; both sides can end up worse than before. Where states do derive a net gain from a successful war, the losses of the losers tend to be greater than the winners' gains[5]. This is not exactly surprising; little is more destructive of human utility than the expenditure of resources with the intent to destroy other resources, which is what warfare mostly consists of.

3. Principal assumptions

The following principal assumptions and issues are known to underlie the analysis. The first three are general assumptions for this branch of international relations and validated by a substantial body of social science, the last two are specific to this study.

- That policy elites, (governments of various types) are generally rational within the constraints of information provided to them;
- That policy elites are generally capable of effectively controlling the actions of their own states[6];
- States seek to maximise their utility according to a consistent scheme[7];
- The use of *actual costs*[8] & *outstanding benefits*[9] as a proxy[10]; for expected cost/benefit
- The problem of "censured data"[11] is not overly distorting.

4. Data and coding

The study data was drawn from a set of interstate 20th century conventional conflicts. In a few cases exceptions were made for sub-state actors who approximated to states as functioning political entities with predominant control and disposition of resources within a defined geographical area.

As is usual with HA studies, the data were collected by external historians and subject to internal cross-checking. Two separate teams were used successively:

- Initial set of 25 interstate conflicts collected by historians under contract to HVR Consulting.
- Secondary set of 13 interstate conflicts collected by historians under contract to Kings College London.

This iterative process allowed weaknesses in data, case selection, definitions and criteria to be eliminated whilst new criteria were added. The resultant data comprised of 107 data serials, each one representing a major participant state involved in a particular war.

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[4] It should be noticed that this is generally true even when the state is not the principal aggressor. Any state can stop the fighting at any time, by surrendering unconditionally, but that choice has costs all of its own…

[5] A game of roulette affords a good analogy of a negative sum game as far as non-house players are concerned; some may leave the game with net winnings, but statistically speaking the house margins ensure that they suffer net losses as a group.

[6] Importantly, this assumption can break down in extreme cases, were the policy elite is itself destroyed by the war, or loses effective control through widespread civil disorder etc. Hence "total wars" fought to decisive victory may violate this assumption (though are not analytically useless, because the direction of error that they introduce is known).

[7] A useful objection here is that the scheme of utility for the policy elite may not be synonymous with that of the state. This is addressed elsewhere in the IR literature and I cannot treat it fairly here.

[8] ACTUAL COSTS: What the state has suffered/gained from fighting so far.

[9] OUTSTANDING BENEFITS: The remaining war aims the state could potentially fulfil by continued fighting.

[10] An attempt to ascertain the mental states of the policy elites involved from historical records would be fraught with potential error. However, the empirical condition of their states, and the objective held, are much less in dispute amongst historians. Hence, the use of existing costs / benefits at conflict termination are preferred as indicating the direction in which further fighting would have progressed.

[11] Basically, that there are no data points sampled above the *true line* of expected cost/expected benefit (states that are winning) but only on the line *or below it*. Hence, the coefficients of any line fitted to this data are lower than those derived from the "true" line. The analytical effect of this sampling bias is to depress the value of coefficients associated with outcome cost (see the analysis section).

For each serial, a series of data fields was collected. These data fields described the policy aims[12] of the state in waging war, and the outcome of the war with respect to that state.

- The Benefits fields described the objectives the state held in waging war, and were classified for both the states Initial and Final war aims. They were coded as success, partial success, failure or not present.
- The Costs fields described the physical consequences of the war for the state involved, such as loss of territory, casualties, etc. These were typically coded into binary or ordinal values[13].

The major data fields are listed in Table 1. A full description of these fields can be provided on application to the author.

Benefits	Costs
Regime Survival	Regime Status
Regime Change[14]	External Mediator
Economic	Economic Gain / Loss
Territorial [3 categories]	Territory Gain / Loss [3 sub categories]
Military Security	Ground Forces Balance
Demographic	Naval Forces Balance
Protection of Nationals	Air Forces Balance
Alliance Commitments	Diplomatic Gain / Loss
Policy Change (Domestic)	Foreign Policy Modification
Policy Change (Foreign)	Domestic Policy Modification
Domestic Popularity	Social Unrest
	Casualties (as % population)
	External intervention
	Termination status
	Termination initiator

TABLE 1 – Data fields

5. Analysis

FITTING WAR AIMS AND OUTCOME TO A MATHEMATICAL MODEL

The data describes the conditions prevailing at the point of conflict termination. Using the rational expectations hypothesis, we know that in these conditions the state believes that expected cost exceeds expected benefit. Given that, we are taking actual costs and outstanding benefits as proxies for expected costs and benefits. In this situation, the war aims fields can be seen as corollaries for outstanding potential/expected benefit, whilst the outcomes are equivalent to potential/expected cost. Hence we have an equation of the form[15]:

$$\alpha_1 B_{1,z} + \alpha_2 B_{2,z} + ... \alpha_I B_{I,z} = \beta_1 C_{1,z} + \beta_2 C_{2,z} + ... \beta_J C_{J,z} + E_z$$

EQUATION 1 – The rational expectations model of conflict termination

Where:

- B refers to the set of benefit variables
- C refers to the set of cost variables
- I and J are the population numbers for the data fields used
- α and β are the coefficients expressing the relative (dis)utility of benefits and costs respectively

[12] Note that much existing conflict termination work does not take into consideration the policy aims of the participants, just the outcomes. This can result in wars of national survival being indistinguishable from border disputes, with resultant difficulty in predicting the costs either side are willing to bear in its prosecution.

[13] i.e. the "Economics" outcome field took values defined from +3 (massive economic gains in course of conflict) to –3 (ruinous economic losses in the course of a conflict) with a score of 0 reflecting no change from the outset.

[14] The complement of regime survival. Regime change signifies the state desires the destruction of another state, Regime survival indicates where the state is concerned with it's own survival.

[15] Actually, the outcome variables allow for gains as well as losses, (i.e. territory), but for the purposes of clarity, this paper will consistently talk about the benefit associated war aims and the cost of war outcomes.

- z is the war and state serial (i.e. Britain in WWII, Israel in Yom Kippur War etc.), total population Z = 107
- E is the error, which converts the expression from an inequality[16].

From this, we wish to derive values for α and β in Equation 1, which will provide us with utility values for war aims and war outcomes. These values are those occurring at the best fit of the model, where the sum of errors is minimised. Hence, the minimisation:

$$Min \sum_{z=Z}^{z=1} E_z^2$$

EQUATION 2 –Minimisation of sum of squared errors

ORDINAL VARIABLES AND QUANTITATIVE SCORING

However, ordinal cost variables could not be implemented in the above minimisation, so it was necessary to transform them into sets of binary dummy variables. A similar conversion was done with the war aims variables, which were also ordinally ranked by expected utility[17].

SOLVING

The system was solved by a genetic algorithm, optimising the coefficients against the sum of squared errors[18], which converged in ~250 generations. Initial values were randomly distributed lognormally about 1 (as the null hypothesis would be that all variables had equal utility). The coefficient values of each potential solution set were re-normalised about a geomean of 1 at each generation of the algorithm. This ensured consistency between solution sets and hastened convergence.

This method was chosen as:

- problem may be non-linear
- many binary variables
- problem generally unconstrained
- quicker to code and implement!

Some alternative forms of solving were considered, including Newton-Raphson optimisation and ordinal regression. These modes were discontinued due to time and resource constraints, but may remain useful avenues for further effort.

6. Results

The study results provided:

- Validation of the rational expectations hypothesis; that there existed a clear relationship between the set of objectives (war aims) pursued by a state in conflict and the costs (outcomes) it was willing to sustain in the course of fighting.
- Initial estimates of values of Benefit and Cost coefficients associated with given war aims and outcomes.

Whilst the detailed numbers are classified beyond the scope of this paper (interested parties are welcome to apply to author or MoD sponsor for further discussion), we can highlight a few of the general points where they uphold or challenge previous findings in the conflict research literature:

- Regime survival is indeed the most highly valued benefit, followed by "obvious" realist factors like

[16] The initial rational expectations formulation would be that of "outstanding war aim benefit > expected outcome cost". The addition of an error value converts this expression to equality.

[17] War aims scored as "not present" had less expected benefit than "successful" which in turn had less expected benefit than "unsuccessful". This slightly counter-intuitive ranking can be understood as a nation with unfulfilled objectives has more incentive to fight on than a nation that has accomplished all of its objectives.

[18] A few alternatives were tested, such as cost-benefit ratios, but as none yielded an obvious improvement in terms of explained / unexplained variance, the simplest model was adopted.

territory, economics, etc.

- Casualties (either absolute or relative) *overall* show a relatively weak cost[19]
- "Endowment effect"; decreasing marginal value of benefits, increasing marginal value of costs.

By conducting multiple runs of the genetic algorithm it was possible to:

- determine from F-tests of the inter-run / intra-run variance that individual cost and benefit variables were themselves significantly different from zero.
- gain assurance that the system was stable and repeatedly converging to the same region.

The overall fit of the results can be described by plotting the composite costs against benefit variables. Ideally, all points should lie upon the resultant line that should trace towards the origin, with residual error shown as scatter about the line. This yields an r^2 of 0.51 on a linear plot, (Figure 2 shows a weighted model with 0.41 r2 but with better agreement with theoretical line), with the gradient of the line significantly different from zero, at >99.9%.

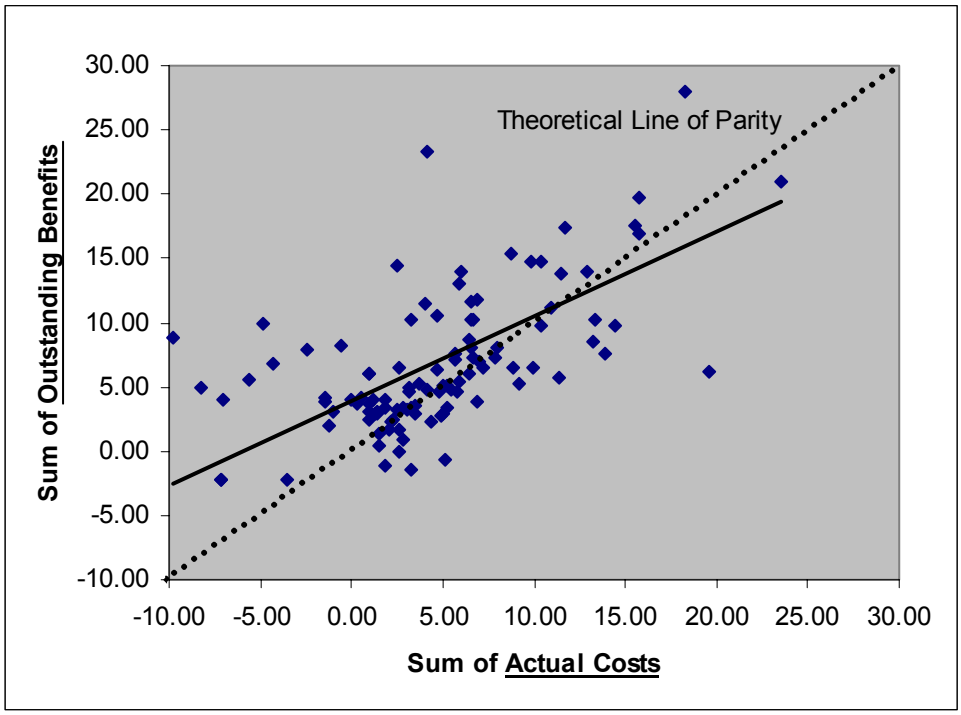

FIGURE 1 – Distribution of cost against benefit variables by cases

7. Application of the Rational Expectations Model

Given a set of cost and benefit coefficients associated with specific war aim and outcomes, it is possible to construct a simple model which predicts whether states will seek to withdraw from conflict as a function of the "damage" sustained and their own objectives. Figure 2 gives the cumulative distribution of the State's expected utility proxies ([outstanding benefit] – [actual cost]) at the point of termination. Note that the gradient of the frequency line gives a measure of how well the analytical assumption of rational expectations is upheld by the fitted empirical data[20].

[19]This variable has not so far been tested separately for casualties accruing to democratic and autocratic regimes; the author notes the literature hypothesis that the former are much more sensitive to it.

[20] A vertical cumulative frequency line would indicate a wholly perfect fit. A horizontal cumulative frequency line a wholly imperfect fit. When considered in conjunction with the range of values for benefits and costs, an expression for the gradient can be taken as measure of goodness of fit, or the marginal change in y over marginal change in x. This relates to a coefficient of about 0.5

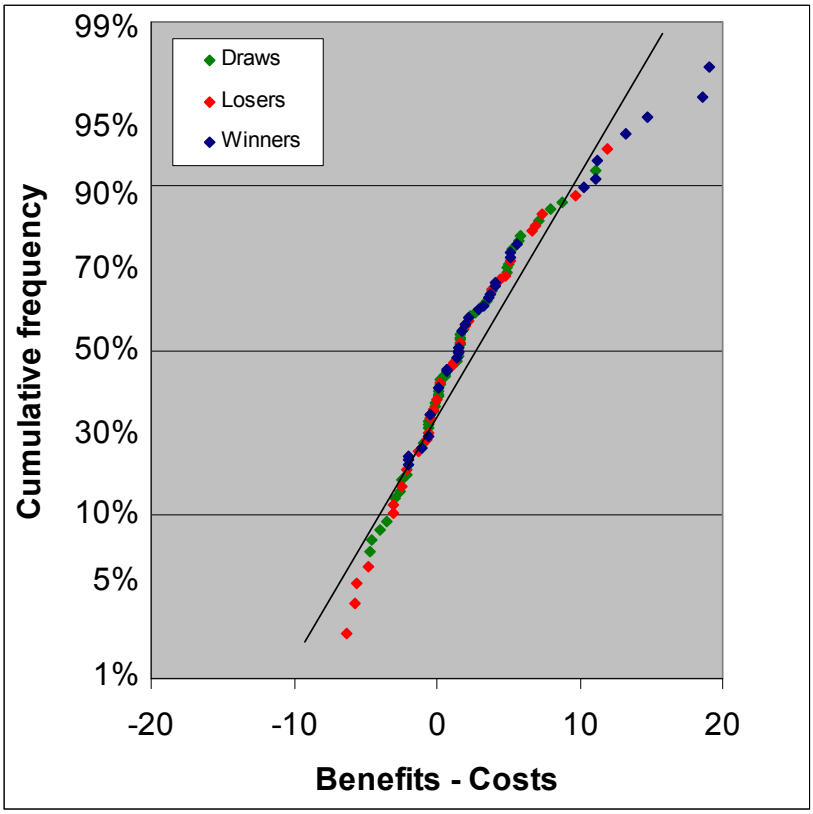

FIGURE 2 – Cumulative frequency of conflict termination

Note that the "winners" and "losers" have been marked separately to examine potentially systemic error. Though some cluster at their respective ends, the majority are interspersed. This is in line with expectations[21].

The process for using the model is as follows:

- Determine the war aims of the state. Sum the benefit variables associated with these war aims.
- Determine the sum of actual costs that have been sustained by the state. Sum the costs variables associated with these outcomes.
- Deduct the first total from the second. Reference the total on the x-axis of Figure 3, and read the likelihood of the state seeking peace from the y-axis.

Note that the axis is slightly shifted away from 0 net utility value at P=50%; this is probably due to a known sampling biases[22] depressing the value of the cost values. This is further indicated by the line of best fit in figure 1 holding a gradient less than parity; indicating that the coefficients for costs are under-estimated.

8. Discussion and known issues

The study results provide a genuine advance in the analysis of international relations, and a validation of the rational expectations model as applied to conflict termination. There appears to be a demonstrable relationship between the

[21] Net *expected utility* for both "winners " and "losers" should be distributed about 0. Note that outstanding benefit (aims remaining to be fulfilled) is *not* the same as existing benefit (aims already fulfilled). Obviously, the winners have systemically higher existing benefits than the losers. The notable "trailing edge" winners and losers of the distribution are generally the "total war" cases where the assumption of state control of termination is being stressed.

[22] Ironically, both "total war" and "easy win" cases will tend to set estimate outstanding benefit lower than true actual outstanding benefit, and hence depress the corresponding cost coefficients relative to the rest of the data.

objectives of a nation and the costs it is willing to bear in conflict. This represent a step forward on the majority of most predictive models of conflict termination by considering the stakes involved for both sides, without which the outcome costs can appear highly variable.

Several issues were identified during the analysis that may account for some of the residual variance or which involved the study assumptions being violated. They are not felt to be either insurmountable or gravely distorting to the present results, but comment and suggestions are welcomed on the following:

a. Possible statistical / mathematical refinement

(1) Limitations of the genetic algorithm in finding a global solution; is there a better way through ordinal regression? (Although this has been addressed to some extent through sensitivity testing on runs and limited cross-validation).

(2) Tighten estimates of global maxima and provide an estimate of the covariant matrix.

b. Analytical considerations

(1) Include duration of the conflict as a cost function

(2) Separate out state actors by type – do democracies value some outcome variables (i.e. casualties) more then dictatorships?

c. Data improvement

(1) Known sampling bias tending to depress the value of cost variables.

(2) Uneven error on model, with more variance at lower values on both axes. This indicates problems of resolution in fitting limited costs and benefits to a system that has to encompass such a wide range of outcomes.

(3) Symmetry of aims. Ideally, war aims should describe the same quantity of thing for both sides; i.e. both the defence of territory and acquisition of territory can be scored as a “territorial aim”.

d. Data expansion

(1) There are plenty of inter-state wars remaining, but how far back can the analysis be reasonably extended?

(2) Sub state actors and civil wars. It has been suggested that the model could be expanded to cope with sub-state actors if the cost and benefit variables were re-written. Are insurgent groups sufficiently rational and definable in their cost and benefit variables to be the subject of such a model?

Finally, the author would like to thank his colleagues in the Dstl HA team and especially our MoD customer, DG(S&A), without whose valued support, criticism, suggestions and funding this work would not have been possible. Such errors as remain, are of course, wholly his own.