A GAME-THEORETIC APPROACH OF WAR

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Preliminary Draft: January 2007

ABSTRACT

In this paper I seek to answer the question: why states engage in armed conflict against other states? I make the argument that armed conflicts are conducted as a way of acquiring economic gains. This idea was expressed back in 1974 by Gordon Tullock who stated that "gain (or avoidance of loss) is the common reason for undertaking warfare". Accepting the proposition that war is a rational act, that is, it is the outcome of a rational decision process, thus to explain its occurrence I will utilize a game-theoretic model that describes such a process.

Keywords: War, Game Theory, Bargaining Game.

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"Nearly all wars end not because the states that are fighting are incapable of further fighting but because they agree to stop. Thus to explain why wars occur one must explain why states must fight before reaching agreement, which implies that war must be considered part of the bargaining process that leads to a negotiated settlement and not as an alternative to it".
R. Harrison Wagner (2000, p.469)

1. Introduction

The history of the world is replete with instances of war.

Since the end of World War II, it is estimated that at least 8 million people have died in the course of combats in civil and international wars (International Peace Research Institute (PRIO), 2005), and there have been around 228 armed conflicts in 148 locations all over the world, according to the Uppsala University/PRIO criteria, which require a minimum of 25 battle-related deaths per year to define a conflict episode as armed conflict.

However, the trend in war and killing during the period from 1946 to 2005 was not uniform. From the beginning of the Cold War – the period from the late 1940s to the late 1980s – to 1991, the number of armed conflicts increased greatly, with most of the killing taking place in developing countries. Those were mainly colonial and post-colonial wars, and armed conflicts driven by the geopolitics of the Cold War. After 1992 the number of wars started to decrease from 51 to 39 in 1998 and by 2004 that number had dropped to 30 (PRIO, 2005). This was accompanied by a decrease in the number of battle-deaths, and a decrease in the number of unarmed population killed.

Although we have been witnessing decreased number and intensity of international armed conflicts, wars are still prevalent around the globe. Major internal wars fought with United States involvement such as in Iraq, Darfur, Afghanistan, and Somalia. Guerrilla and civil wars in Balochistan (Pakistan), Myanmar, Democratic Republic of Congo, Ivory Coast, Sri Lanka, Nepal, Thailand, Colombia, West New Guinea (Indonesia), Casamance (Senegal), Western Sahara, Nigeria, Cabinda (Angola).

The destructive consequences of war would suggest that war is not a "rational" act. Hence, one needs to ask why states engage in destructive wars against one another. Lately, the political economy literature on war focuses on civil wars, given the decreasing number of international wars. A substantial number of these studies explain the causes of armed conflicts through regression analysis (Bennett and Stam 1996; Reed 2000; Collier, Hoeffler and Soderbom 2004; Cunningham, Gleditsch and Salehyan 2006), while other set of studies construct bargaining models of war (Morrow 1989; Fearon 1994, 1995; Wagner 2000).

Sandler, Dockson, Dockson and Hartley (2003) provide a vast selection of published studies on the economics of conflict. Lapan and Sandler (1988) present a game-theoretic framework to determine those situations when a government would want to pre-commit itself to a non-negotiation strategy, analyzing the case of terrorist incidents. Bellany (1999) offers a general mathematical model of war and uses it to explain duration of war as well as shifts in military strategy. Collier and Hoffler (2002) seek to explain conflict in terms of outcome and modeled war as "an industry that generates profits from looting" (Collier and Hoffler, 2002, p.2). Thus, armed conflicts are conducted as a way of acquiring economic gains. This idea was expressed back in 1974 by Gordon Tullock who stated that "gain (or avoidance of loss) is the common reason for undertaking warfare" (Tullock, 2005, p.311). He specifically asserts that "it is always

rational to start a war if your enemy is both rich enough and weak enough."

If one accepts the proposition that war is a rational act, that is, it is the outcome of a rational decision process, then to explain its occurrence one needs a model that describes such a process.

In this essay I will utilize a bargaining game where war is the preferred choice. The bargain takes place between two states.

This paper is organized as follows. Some definitions and concepts are given in section 2. The literature review is presented in section 3. Section 4 spells out the theoretical model and section 5 provides a brief conclusion and plans for future research.

2. Definitions and Concepts

An inspection of the literature on conflict discloses many terms about war and conflict. Non-violent and violent conflict, conventional and nuclear war, intrastate war, extrastate and interstate war, imperialist war, guerilla war, revolutionary war, accidental and premeditated war, offensive and defensive war, are but a few of the many terms associated with conflicts.

The Heidelberger Institute for International Conflict Research (HIIK) defines conflict as "the clashing of interests (positional differences) on national values (territory, secession, decolonization, autonomy, system/ideology, national power, regional predominance, international power, resources, other) of some duration and magnitude between at least two parties (organized groups, states, groups of states, organizations) that are determined to pursue their interests and win their case" (2002, p.2).

The International Peace Research Institute (PRIO) and the Uppsala University Conflict Database (UCDP) defines it as "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, in which at least one is the government of a state, results in at least 25 battle-related deaths" (2006, p.4).

Anderton (2003, p.98) defines conflict as "the use of resources for creating or defending against appropriation. A broad context of conflict encompasses crime, corruption, litigation, strikes, rent-seeking, and international and intra-state hostility. Within each of these areas, economic agents allocate resources toward the defense and coercive appropriation of assets."

While some conflicts are resolved peacefully, others involve the use of violence. In terms of intensity, conflicts are normally categorized as non-violent and violent conflicts.

The Heidelberger Institute for International Conflict Research identifies five conflict categories by intensity level: latent conflict, manifest conflict, crisis, severe crisis, and war. The most important difference between these conflicts is that the first two are of nonviolent nature, while the crisis, severe crisis and war include usage of violence during the conflict. The last stage of conflict – war – is defined as the stage in which "violent force is used with a certain continuity in an organized and systematic way. The conflict parties apply extensive measures, according to the situation. The amount of destruction is vast and of long duration" (2003, p.2).

Cioffi-Revilla (1996, p.8) offers a definition of violent conflicts in terms of the purpose and magnitude of the violence, as the "occurrence of purposive and lethal violence among two or more social groups pursuing conflicting

political goals that results in fatalities, with at least one belligerent group organized under the command of authoritative leadership."

The categorization of conflicts as non-violent and violent creates the problem of identifying when the line dividing non-violent conflict from violence has been crossed. A non-violent conflict turns into a violent one when a peaceful act (such as demonstration) turns into a violent confrontation given rise to battle death. A quantitative threshold has been identified in order to discern degrees of violent conflicts or wars. The first attempt to fix the threshold quantitatively was made by Richardson (1960) who defined it as 1,000 conflict deaths.

Singer and Small (1972) also pick war threshold as 1,000 battle deaths (not counting, therefore, the indirect victims through famine, lack of shelter, and disease). Singer and Small went further as identifying war episodes as conflicts in which at least one of the combatant parties is a state.

The Stockholm International Peace Research Institute (SIPRI) gives the following definition of war and its quantitative threshold:

"A major armed conflict is defined as the use of armed force between two or more organized armed groups, resulting in the battle-related deaths of at least 1,000 people in any single year" (2001, p.15).

The PRIO/Uppsala University Conflict Database also use the battle-related human casualties' thresholds to distinguish between major and minor violent conflicts. It divides armed conflicts into two subsets by level of casualties: Minor Armed Conflict, resulting in between 25 and 999 battle-related deaths in a given year; and War, giving rise to at least 1,000 battle-related deaths in a given year.

Conflicts can also be categorized by type: international conflicts, which take place between two or more states, and civil conflicts, which occur between one state and an "internal" opposition groups.

The PRIO/Uppsala University Conflict Database and the Correlates of War Project differentiate between several types of conflicts: interstate (military conflicts between states), extrastate (between states and non-state players), internationalized internal (between the government of a state and internal opposition groups with intervention from other states) and intrastate (within states). Although all violent conflicts have similar outcome, the motivation for initiating the violent conflict may or may not be the same in all these types of conflicts.

In this essay, I adopt the definition of interstate war as a contested incompatibility that concerns government and/or territory where the use of armed force between two states results in more than 25 battle-related deaths.

3. Literature Review

The literature offers diverse perspectives on war. Almost every academic discipline has contributed with both theoretical and quantitative studies of armed conflicts. Thus, in this essay the literature review will be limited to those studies that offer insight into the decision process leading to war.

The study of war as a violent conflict was mainly carried out by political scientists who addressed several aspects of war, from its onset, duration and termination to the prediction of war outcome, negotiation of terms of settlement. Many studies present a general model of conflict, and some studies analyze specifically the case of interstate armed conflicts. Regression analyses were used by researchers including Bennett and Stam (1996), Bennett (1998), Reed (2000), Slantchev (2004) and Fearon (2005) to investigate these issues. Political scientists have also analyzed the behavior of different groups involved in conflict using the tools of

economic theory – notably game theory (Morrow 1989; Banks 1990; Fearon 1994, 1995; Werner 1998; Wagner 2000; Filson and Werner 2002).

Economic research on conflict dates back to the 1960s[1]. Schelling's (1960) "The Strategy of Conflict" has pioneered the study of bargaining and strategic behavior applied to war. In this book, Schelling introduces the concept of the focal point, which he describes as the solution that people will tend to use in the absence of communication, because it seems natural, special or relevant to them: "focal point[s] for each person's expectation of what the other expects him to expect to be expected to do" (1960, p.57). His economic theories about war were extended in "Arms and Influence" (1966).

Tullock's (1967) study on economics of theft noted that interest group activities consumed resources and, hence, are analogous to theft, insofar as new policies shifted income and wealth from one group to another without compensating the original "owners." Such resources were part of the welfare cost of those policies, because the resources devoted to lobbying could have been used in other more productive activities or harmlessly used as personal leisure. The next important step in Tullock's reasoning — and for the rent-seeking literature that later emerged — was the introduction of the idea that if interest groups could induce government to shift wealth from others to their members, such activities would be an attractive investment. In his 1980's paper "Efficient Rent Seeking", Tullock demonstrates that Nash equilibrium investments by rent-seekers increase with the number of players and with returns from the activities that determine their probability of success.

Following the rent-seeking concept introduced by Tullock, Hirshleifer (1988) incorporates the analysis of profitability of war in a general-

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[1] A compilation of studies on conflicts and wars appears in Sandler, Dockson, Dockson and Hartley (2003).

equilibrium Cournot and Stackelberg models, assuming various intensity of conflict, and considers the trade-off that groups face between productive and appropriative activities.

Tullock (1974), Hirshleifer (1989), and Fearon (1995) note that wars induce large investments that reduce the value of the prize sought. Resources are consumed by opponents in the war, and the value of the prize may be damaged by warfare as the intensity of conflict increases. Furthermore, even in times of peace, considerable resources may be devoted to obtaining and retaining territorial and property claims.

In his 1974 paper, "The Social Dilemma: The Economics of War and Revolution", Tullock provides an economic explanation of international conflict as a way to appropriate wealth or avoid losses. He presents the conditions, in terms of costs and benefits, which make a war profitable; the circumstances that contribute to an increase in the likelihood of success of a nation; and introduces the idea of miscalculations in the decision-making process which may explain "investments that turn out badly" (1974, p.311).

Neary (1997) uses an economic model of conflict to show that increases in the level of wealth have the effect of increasing the equilibrium level of military, or "wealth-diverting", expenditure.

Recently, a significant fraction of the empirical literature on violent conflicts has focused on civil wars onset and duration, analyzing the ways rebel groups and governments finance themselves and recruit soldiers, and the intervention of other states and relief agencies (Collier 2000; Collier and Hoeffler 2002; Fearon and Laitin 2002; Fearon 2005).

In terms of interstate wars, the relationship between wealth and the onset and duration of interstate wars has been studied by several authors giving rise to conflicting results (Choucri and North 1972; Zuk 1985; Meldrum 2000;

Nest 2001). Choucri and North (1972) empirically evaluate, using a two-stage least squares instrumental variables approach to time series analysis, a model of territorial expansion and international conflict during 1870-1914. They argue that the territorial expansion of the major powers, and the resulting armed conflict between them, is the result of scarcity of resources, which leads to the need to control resources in poorer economies. Whether the major powers will succeed in obtaining those resources from international sources depends on the size of their population, scale of technology, access to resources, and military capability. Zuk (1985) analyzes the correlation between major power's national growth and defense capability, and their territorial expansion, during the period 1870-1913, and concludes that countries were able to provide for their own resource needs or access the resources through trade with other states. Increasing resource supplies from the major powers tended to coincide, according to Zuk, with the industrial and demographic growth, and also with an increased military capability. However, some other studies have found a link between the existence of natural resources and the increased probability of war onset and duration, through the finance of the campaign provided by the direct trade of those resources, the intervention of third parties seeking raw materials, and the appropriation of those resources from the attacked state (Meldrum 2000; Havermans 2000; Nest 2001).

Prior crises appear in some studies on interstate conflict (Fearon 1994b; Bennett and Stam 1996). Fearon (1994b) relates the defender's behavior in past confrontations with the outcome of the current crisis. He concludes that the existence of a previous crisis between the states affects more the outcome of the current crisis than the defender's bargaining style in the last conflict.

The war-costs variable appears in Fearon (1994a), Bennett and Stam (1996), Werner (1998), and Filson and Werner (2002). Werner (1998) argues that the belligerents' ability to impose costs affect war outcome. Filson and Werner (2002) also suggest that the anticipated costs of war affect whether the challenger can credibly threaten to attack: the expectation of high costs acts as a disincentive to armed conflict.

Regime type is considered to have different effects on war duration and terms of settlement. Werner (1998) concludes that the belligerents' regime type does not affect the terms of settlement. Bennett and Stam (1996) find, using interstate war episodes from COW and Dupuy and Dupuy (1986) between 1816 and 1985, that regime type affects the duration of interstate wars: wars in which highly democratic states participate are shorter than those that did not participate.

The relative size of the populations is considered to have different effects on war duration, and on its outcome. Zuk (1985) argues that conflict between major powers is related with the industrial and demographic growth, and also with an increased military capability. Bennett and Stam (1996) conclude that the relative size of the populations does not affect the length of interstate war.

Studies using bargaining models of war have offered some relevant insights for understanding the causes of interstate wars.

Since wars are costly and many conflicts can be solved through bargaining, private information and misperceptions are seen as an important source of war onset (Blainey 1973; Banks 1990; Fearon 1994a, 1995; Wagner 2000; Filson and Werner 2002). In most of the bargaining models of war the role of incomplete information in generating inefficiencies has been recognized. What prevents a negotiated agreement in many instances is conflicting expectations about the

performance of military forces and/or the behavior of the other party to the conflict. This argument has been used not only to explain why countries engage in expensive disputes, but also to explain war termination since war can be seen as a way of revealing information about military capability of each side (Wagner 2000). Wagner also argues that because wars are a way of revealing information, the focus of the analysis must be on bargaining while fighting.

On war duration, termination and negotiation of settlement, one important finding of this strand of literature is that there is a link between the costs of the war and the decision to end or continue a war (Carrol 1969, 1970; Filson and Werner 2002; Slantchev 2004). Filson and Werner (2002) argue, using a bargaining model of war, that if the war is prolonged, then it becomes increasingly likely that it will end in a defeat for the attacker. This is the result of what they refer to as the "screening effect", since weak defenders tend to accept settlements early in the bargaining game.

However, the studies listed above are theoretical models of wars and do not provide empirical tests of their findings. Fearon (1994b) and Werner (1998) are two of the published studies empirically testing a bargaining model of war.

Fearon (1994b) describes a bargaining game with asymmetric information of an international crisis and develops some hypotheses relative to the impact of relative military capabilities and political interests on the efficacy of threats made during the conflicts. The hypotheses are tested using 58 cases of international disputes involving three states – a defender, a challenger and a protégé – from 1885 to 1983, collected by Huth and Russett (1988), using both logit estimation and correlation analysis. Fearon

concludes that the existence of alliances between defender and protégé is related to the failure of deterrent threats by challengers.

Werner (1998) uses a bargaining model of complete information to analyze how costs, political risks, and regime type affect the final settlement terms. The bargaining model hypotheses are tested using an ordered logit in the period 1816-1980. The empirical results suggest that while duration of war is not indicative of the magnitude of the final settlement terms, the higher the state's ability to impose costs on the opponent the more favorable the terms of settlement.

Another issue dealt with in the literature is the type of costs that is associated with undertaking warfare. In addition to the economic costs, Fearon (1994a) identifies another type of costs, political costs or "audience costs", associated with the decision of backing down during a conflict, which increases as the crisis escalates. The existence of political costs enables countries to learn about the opponent's willingness to fight in a dispute, since leaders will be locked into their position due to adverse domestic political costs of backing down. Werner (1998) considers the existence of political costs, which is the probability of removal, each time a leader chooses to continue the war rather than settling, during the bargaining process of war. This is explained by the fact that domestic constituents may dislike the redirection of resources away from productive activities to fund the war. Werner concludes that increased costs of war lead to a decrease in the ability of a leader to negotiate advantageous settlement terms.

In short, the literature on violent conflict has identified the existence and the value of natural resources, private information and misperceptions about the performance of military forces, and the economic and political costs of warfare as important determinants of war onset and its duration.

4. The Game Theoretical Model

Using a game-theoretic model, here I describe the players' payoffs and construct some hypotheses regarding the conditions that lead states to prefer costly war over a negotiated agreement. I start by discussing equilibrium behavior when the states know each other's military capability and values for conflict. Next, I develop a model with uncertainty about military capabilities.

The model describes the process that makes an interstate conflict to evolve to a violent conflict – war. It consists of two countries: one attacker A and one defender D.

Both countries have an initial level of economic resources. A has resources R_A and D has resources R_D, and it is assumed that the level of initial resources do not need to be equal.

The objective of both attacker and defender is to maximize their expected utility which depends solely on the wealth level of the country. The game begins with country A making an offer to country D – D gives up a share of its resources gR_D. According to its payoff, country D will choose between accepting and rejecting the offer. That is, it will choose between a war involving countries A and D, and a negotiated settlement.

Attack is a decision that entails costs and benefits. The benefits are given by the possibility of appropriating resources from the other country. The costs associated with an attack are related with the military resources used in the war.

Thus, when country A chooses to attack country D its expected payoff is determined by country A's own wealth, and the appropriation of country's D wealth, and the cost of attack.

$$U_A^W = d(R_A - C_A) + (1 - d)\left[(R_A - C_A) + (R_D - C_D) \right] \qquad (1),$$

where d is defined as the probability of A being defeated by D. d is introduced in the equation because the acquisition of D's wealth is uncertain. It depends on A's military capability of defeating D.

Uncertainty in the model is introduced through the military capability, which determines d. d is assumed to be uniformly distributed over the unit interval as $d \sim U[0,1]$. The closer to one is d, the higher the chance of country D winning the battle. That is, if $d = 0$ it means that the defender D, has probability of 0 to win the battle. On the other hand, if $d = 1$ it has probability of 1 to win.

In the case of country D, its expected utility in the case of a war is given by:

$$U_D^W = d(R_D - C_D) + (1 - d)0 \qquad (2).$$

If country D wins the war, it bears the cost of the military resources used in the war. If it loses the war, its payoff is normalized to zero.

Equilibrium under complete information

Assuming perfect and complete information about each country's military capabilities, the backwards-induction outcome of the game can be calculated.

I assume the game has two stages. The game starts with one side, A, making an offer to the opposition side, D. The offer – D gives up a share of his economic resources $\boldsymbol{g}R_D$ – is either accepted or rejected. Country's D second-period decision amounts to choosing between accept or reject country A's offer. If country D accepts the offer, a peaceful settlement is

reached; while a rejection implies an armed conflict between the two countries.

To compute the backwards-induction outcome of this game, I start at the second stage. Here country D faces a choice between accepting and rejecting country A's offer.

If country D accepts A's offer its payoff is given by:

$$U_D^N = (1-g)R_D \qquad (3).$$

If country D rejects the offer, it will sustain the costs of fighting. Its payoff is given by equation (2) as: $U_D^W = d(R_D - C_D)$.

Therefore, country D's choice is between the negotiated-settlement payoff, U_D^N, and the utility level after a war, U_D^W. Country D will be willing to accept country A's offer if and only if $U_D^N \geq U_D^W$.

At stage one, since country A can solve country D's second-stage problem, it anticipates country D's reaction to the offer, g. Thus, country A's problem at the first stage amounts to choosing the maximum level of economic resources that country D would be willing to give up. That is, the level of resources that would make country D indifferent between a negotiated agreement and a war. This level of resources is calculated by equating country D's utility levels U_D^N and U_D^W, as:

$$(1-g)R_D = d(R_D - C_D) \qquad (4).$$

Solving for g,

$$g = \frac{(1-d)R_D + dC_D}{R_D} \qquad (5).$$

Since both countries have complete information about each country's military capabilities, d is known.

To verify the optimal choice of country A, one needs to assure that the condition $U_A^N \geq U_A^W$ actually holds. That is, that country A will always make an acceptable offer to country D, since its wealth level under negotiated settlement, U_A^N, is higher than its wealth level after a war, U_A^W. Substituting g into U_A^N and U_A^W, we can solve for $(U_A^N - U_A^W)$ as:

$$U_A^N - U_A^W = R_A + (1-d)R_D + dC_D - \left[R_A - C_A + (1-d)(R_D - C_D) \right] = C_A + C_D \geq 0.$$

This result implies that $U_A^N \geq U_A^W$.

Thus, in the backwards-induction outcome of this game, country A makes the offer $g^* \leq \dfrac{(1-d)R_D + dC_D}{R_D}$ and country D accepts. War will never occur.

Equilibrium under incomplete information about resolve

Unlike games of perfect information, in the games with imperfect information (Bayesian games), at least one player is uncertain about another player's payoff function. While with perfect information war does not occur because the outcome of the game can be seen in advance; when imperfect information is assumed, war can occur because states cannot predict the outcome of the war.

I assume that uncertainty is one-sided. The defender has complete information about the attacker, but A does not have complete information about D. As mentioned previously, uncertainty in this model only refers to military capability d: the attacker does not know the defender's military ability.

I analyze a three-period game of incomplete information. In this model, country A updates its information about D's military type after country D's acceptance or rejection of A's offer.

The timing of the first model is as follows: (1) Nature determines D's military type, d, which it is assumed to be uniformly distributed over the unit interval as $d \sim U[0,1]$; A makes an offer to D – D give up a share of its economic resources $\boldsymbol{g}R_D$; (2) D accepts or rejects the offer; (3) A observes D's choice (but not D's military ability) and then chooses to attack or withdraw the offer; Payoffs are given by U_A^W and U_D^W in the case of war, and U_A^N and U_D^N in the case of negotiated agreement. Figure (1) describes the choices leading to war.

To compute the backwards-induction outcome of this game, I begin by considering the third-stage choice of the attacker as whether to attack or retreat .
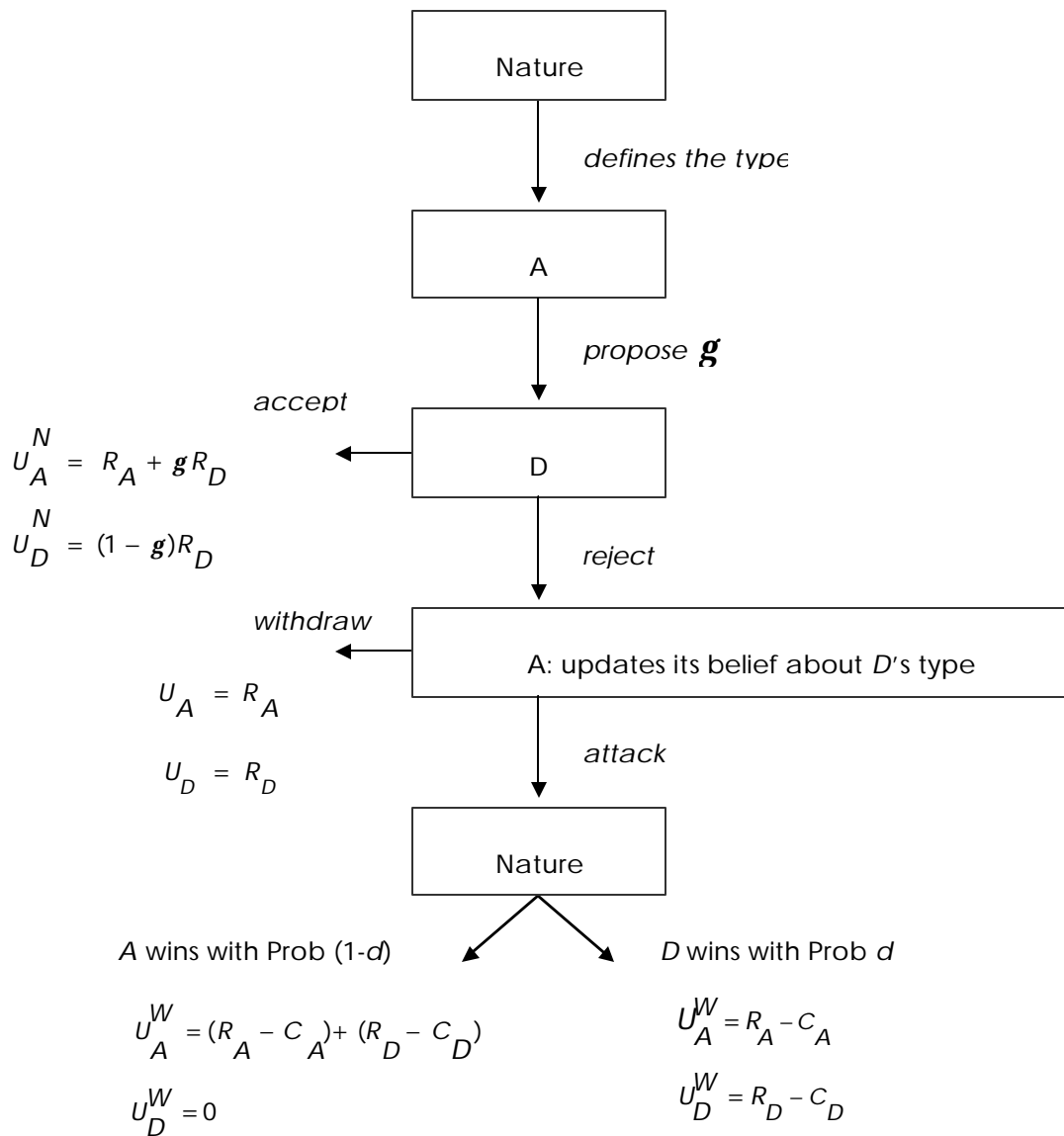
Figure 1. Game of imperfect information

At stage three, after country D rejects the offer, country A will then update its belief about D's type, $d \sim U[\hat{d}(g^*),1]$, and either attack or retreat. $\hat{d}$ is considered to be the type of defender that is indifferent between a war and a negotiated settlement.

If country A attacks, it will win with the probability: $1 - E[d|\hat{d}] = (1 - \frac{E[d]}{1 - \hat{d}})$; and

loose with the probability: $E[d|\hat{d}] = (\frac{E[d]}{1 - \hat{d}})$, given that country D chose to

reject A's offer. Taking averages, $1 - E[d|\hat{d}] = (1 - \frac{1}{2(1 - \hat{d})})$, and

$E[d|\hat{d}] = (\frac{1}{2(1 - \hat{d})})$. Thus, country's A expected payoff of attack is given by:

$$E[U_A^A] = (1 - \frac{1}{2(1 - \hat{d})})((R_A - C_A) + (R_D - C_D)) + (\frac{1}{2(1 - \hat{d})})(R_A - C_A).$$

In order to solve for the type of defender that would make country A indifferent between a war and a retreat, $\hat{\hat{d}}$, I equate the payoffs under attack and withdraw as:

$$R_A = (1 - \frac{1}{2(1 - \hat{\hat{d}})})((R_A - C_A) + (R_D - C_D)) + (\frac{1}{2(1 - \hat{\hat{d}})})(R_A - C_A) \qquad (6).$$

Solving for $\hat{\hat{d}}$,

$$\hat{\hat{d}} = \frac{2C_A + C_D - R_D}{2(C_A + C_D - R_D)} \qquad (7).$$

If $\hat{d} < \hat{\hat{d}} = \frac{2C_A + C_D - R_D}{2(C_A + C_D - R_D)}$ country A will attack country D, otherwise ($\hat{d} > \hat{\hat{d}}$)

it will retreat.

At stage two, country D chooses either to accept or reject A's offer. If D accepts A's offer, its payoff is given by equation (3). If it rejects, its final wealth level depends on whether country A attacks or not.

If A's optimal solution is to retreat, D will only accept A's offer if:

$U_D^A = (1-g)R_D \geq U_D^R = R_D$. Since $(1-g)R_D < R_D$, D's optimal response will be to reject A's offer. That is, for any value of g, D will always choose to reject the offer.

If A's optimal solution is to attack, country D will accept A's offer if and only if:

$$U_D^A = (1-g)R_D \geq U_D^R = \hat{d}(R_D - C_D). \tag{8}$$

From equation (8) we can solve for the type of defender that is indifferent between a war and a negotiated settlement, $\hat{d}$.

$$\hat{d} = \frac{(1-g)R_D}{R_D - C_D} \tag{9}$$

If $\hat{d} > \frac{(1-g)R_D}{R_D - C_D}$ country D will reject A's offer, otherwise it will accept it.

Thus, A's first-stage problem is to solve for the optimal offer, given $\hat{d}$ and $\hat{d} < \hat{\hat{d}}$. The constraint, $\hat{d} < \hat{\hat{d}}$, is considered because if $\hat{d} > \hat{\hat{d}}$ country D will always reject A's offer.

It can be stated as:

$$\max_{g} U_A: U_A^N.\text{Prob}\{D \text{ accepts the offer}\} + U_A^W.\text{Prob}\{D \text{ rejects the offer}\}.$$

Thus,

$$\max_{g} U_A: \hat{d}(R_A + gR_D) + (1-\hat{d})\left[(1 - \frac{1}{2(1-\hat{d})})((R_A - C_A) + (R_D - C_D)) + (\frac{1}{2(1-\hat{d})})(R_A - C_A)\right]$$

subject to:

$$\hat{d} = \frac{(1-g)R_D}{R_D - C_D}$$

and

$$\hat{d} < \frac{2C_A + C_D - R_D}{2(C_A + C_D - R_D)}.$$

After solving the maximization problem of *A*, we have either an interior maximum which satisfies the following condition:

$$\frac{dU_A}{d\boldsymbol{g}} = 0,$$

or a corner solution which satisfies the following condition:

$$\frac{dU_A}{d\boldsymbol{g}} \leq 0.$$

Thus, the optimal offer $\boldsymbol{g}^*$ is given by:

$$\boldsymbol{g}^* = \frac{2R_D - C_D - C_A}{2R_D} \tag{10}.$$

Substituting (10) into equation (9), gives:

$$\hat{d}^* = \frac{C_D + C_A}{2(R_D - C_D)} \tag{11}.$$

The following proposition summarizes the results.

Proposition 1. When $\hat{d}^* > \hat{\hat{d}}$ ($\frac{C_D + C_A}{2(R_D - C_D)} > \frac{2C_A + C_D - R_D}{2(C_A + C_D - R_D)}$), the type of defender that is indifferent between a war and a negotiated settlement exceeds *A*'s threshold of attack, country *D* will always choose to reject *A*'s offer, since it is not a credible threat. Otherwise, when $\hat{d}^* < \hat{\hat{d}}$, *D* can accept, if its true type is lower than $\hat{d}^*$, or reject *A*'s offer and go to war, if its true type is higher than $\hat{d}^*$.

If *D* rejects the offer, the explanation may lie in the fact that it has private information about its own military capability, which the attacker does not have. If *D* rejects the offer, *A* can either (*i*) attack in order to increase offensive advantage and appropriate resources from *D*; or (*ii*) believe that

D is militarily strong and not attack. This follows the idea expressed by Fearon (1995). According to Fearon, in a conflict involving two states, *A* and *D*, if state *D* has private information about either its capabilities or its value for the issues at stake relative to the costs of conflict, then state *A* may not know whether a particular demand will yield war or peace. Lacking this information, state *A* faces a trade-off in deciding whether and how much territory to appropriate: the larger the "acquisition", the greater the risk of war.

From the above bargaining models, it is confirmed that war will not occur when countries have complete information about each other's military capabilities. War can only occur when incomplete information about resolve is assumed. Thus, war is a consequence of one sided-private information.

5. Testing the Model: Future Empirical Work

In the previous section two game-theoretic models were derived describing the players' payoffs regarding the conditions that lead states to prefer costly war over a negotiated agreement. The first model assumes that both states involved in the conflict know each other's military capability and values for conflict. The second model assumes uncertainty about military capabilities. From the models it is concluded that war is a consequence of one sided-private information.

A model of interstate violent conflict will be estimated in order to test the validity of the theoretical model. Since the first model does not give rise to violent conflict, only the second model of imperfect information, in which war can occur, will be tested.

The theoretical model and the hypotheses derived from it can be carried out with the use of data drawn from the Correlates of War Project (COW). COW has information on militarized interstate disputes between 1816 and 2001 (including conflicts with less than 1,000 battle related deaths).

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