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Changing capabilities, uncertainty, and the risk of war in crisis bargaining

Brett V. Benson[1], Adam Meirowitz[2] and Kristopher W. Ramsay[3]

Abstract
Understanding how changes to war-fighting technology influence the probability of war is central to security studies. Yet the effects of changes in the distribution of power are not obvious. All else equal, increasing a country's power makes it more aggressive when making demands or more resistant to accepting offers, but all else is not equal. Changes in power influence the behavior of both countries and can generate countervailing incentives. In this note we characterize the conditions relating changes in war payoffs to changes in the probability of bargaining failure and war. For a variety of cases the strategic effects can be entirely offsetting and no change in the probability of war results from changes in the balance of power, a result sometimes called *neutrality*. When this neutralization does not occur, interesting and sometimes surprising effects can persist. For example, if countries are risk averse and neutrality fails, then supporting the weaker country can reduce the probability of war rather than make war more likely, even though the weaker side will now make higher demands and reject more proposals in favor of war.

Keywords
Crisis bargaining, War, Uncertianty, Game theory

Introduction

How changes in military technology affect the probability of conflict is a central question in international relations. Since at least Wittman (1979), we have known that the relationship between changes in power and the odds that crisis bargaining will turn to war is complicated. All else equal, increasing a country's power makes it more aggressive when making demands or more resistant to accepting offers, but all else is not equal. In the bargaining of international diplomacy, as the rewards to war change for actors, so too do the proposed settlements and countries' willingness to make deals. While we have studied in some detail how substantial or expected shifts in military capabilities affect crisis bargaining and war in dynamic settings with complete information, much less is known about these effects when countries are uncertain about their opponents' payoffs from war (Krainin, n.d.; Leventoğlu and Slantchev, 2007; Powell, 2004, 2006).

In this note we study the crisis bargaining game with incomplete information to describe how changes in the distribution of power affect negotiations and the probability of open conflict. Our theoretical framework will focus on the commonly used Fearon (1995) take-it-or-leave-it bargaining model. In this model a player, country A, makes a proposal for the division of a pie that can either be accepted or rejected by another player, country B. Acceptance leads to peace and rejection leads to war, which is a risky proposition. In particular, war is treated as a costly lottery, providing victory for one side and defeat for the other. In our model there is uncertainty about the payoff from war that may come from asymmetric information about country B's relative cost of war.

After solving for the equilibrium of this model, we will explore how changes in the payoff from war, and the distribution of power in particular, affect important outcomes of interest such as the terms of peace and the probability of war. We provide a characterization of these comparative statics, and show how they depend on the fundamentals of the

[1]Department of Political Science, Vanderbilt University, USA
[2]David Eccles School of Business, University of Utah, USA
[3]Department of Politics, Princeton University, USA

Corresponding author:
Kristopher W. Ramsay, Princeton University 038 Corwin Hall, Princeton, NJ New Jersey 08544, USA.
Email: kramsay@princeton.edu

problem in interesting ways. One important and interesting corollary is that in reasonable cases moving toward a balance of power decreases the likelihood of war, even when such a move makes the proposer more aggressive in its demands.

We are not the first to discuss the source of the neutralizing effect of bargaining in the context of war onset. In fact, it is almost conventional wisdom. Wittman (1979) conjectures and Fearon (1995) shows that in the commonly used take-it-or-leave-it bargaining model of war, the probability of victory has no effect on the likelihood of war. Previous scholars have attributed the result to the assumption of risk neutrality,[1] but as we show it is not risk neutrality but rather the assumption that changes in one player's payoffs exactly offset changes in the other player's payoffs at equilibrium that drives the result. In fact, our main point is that neutrality cannot be attributed to a property of a particular player's utility. Rather, it is related to a joint condition of the preferences of the two bargainers. Although certain assumptions that relax risk neutrality will also introduce the relevant asymmetry, we caution scholars against equating risk neutrality with the neutralization of power shifts through bargaining behavior. We show that risk neutrality is neither necessary nor sufficient for the neutralizing effect of bargaining to obtain.

We think it is important to understand what features and assumptions from the standard bargaining model lead to the neutrality result, because many issues in international relations can be framed as studying the comparative statics relating changes in countries' war payoffs as they bargain in a crisis. Such changes may result from exogenous shifts in the distribution of power (Powell, 1999) or intervention by third-party defenders (Benson, 2012; Werner, 2000; Yuen, 2009). Related to the models of third-party intervention in interstate war are models of third-party intervention in intrastate conflict (Cetinyan, 2002; Kydd and Straus, 2013). Other factors that may influence war payoffs and crisis bargaining include international organizations (Chapman and Wolford, 2010), domestic politics (Filson and Werner, 2004; Tarar, 2006), and previous actions by the disputants in a dynamic setting such as in arms races (Kydd, 2000). In particular, understanding what assumptions lead to bargaining behavior that offsets changes in power is crucial when taking theoretical comparative statics to the data. This is because in many comparative statics exercises the derivation of values of interest are related to changes in the probability of war. For example, suppose you wanted to have a theoretical prediction about the incentive to sell arms to one side of a conflict that had yet to turn to war. Further, suppose that the seller cares about the profit of the sale and the probability of war. In such a world the third party would weigh the dollar benefit of the sale against the change in the risk of open warfare. But if the two sides are risk-neutral and war is a costly lottery, then the sale has no effect on the probability of war. Thus the decision of how many arms to sell depends in important ways on whether the assumptions that lead to the neutralizing effect of bargaining are on solid footing. Thus understanding the conditions that lead to the neutrality result are important for empirical and policy reasons.

In what follows we focus on the take-it-or-leave-it bargaining model because it now represents a popular baseline model and variants of it are used to study a host of other important topics ranging from the effects of the balance of power on conflict (Powell, 1996, 1999; Reed, 2003), to the role of mediation (Kydd, 2003; Rauchhaus, 2006) and domestic politics (Filson and Werner, 2004; Ramsay, 2004; Tarar, 2006), to the efficacy of third-party intervention (Cetinyan, 2002; Kydd and Straus, 2013; Werner, 2000), as well as the impact of alliances and deterrence (Benson, 2012; Yuen, 2009).

Model

Consider a situation where two countries, A and B, are in a dispute that may result in a peaceful settlement or war. We may conceive of the negotiations as relating to the division of some disputed territory or a transfer of wealth to accommodate a difference in policy preferences. An agreement is a pair (x_A, x_B) where x_i is country i's share. The set of possible peaceful solutions is

$$X = \{(x_A, x_B) \in R^2 \mid x_A + x_B = 1 \text{ and } 0 \leqslant x_i \leqslant 1 \; for \; i = A, B\}.$$

Each country has a strictly increasing utility for consuming the resource of $u_i(x_i)$, for $i = A, B$. We normalize the payoffs such that $u_i(1) = 1$ and $u_i(0) = 0$. Thus players have strictly opposed preferences over settlement allocations. Because the first coordinate x_A uniquely identifies any distribution of resources between the two countries, we will write a possible settlement as $(x_A, 1 - x_A)$, and sometimes refer to a proposal as x_A.

Bargaining is modeled as a simple extensive form. The bargaining begins with country A proposing a peaceful settlement of the dispute with a distribution of resources $x_A \in X$. If country B accepts this proposal, a settlement is reached, each country consumes $u_i(x_i)$, and the game ends. If country B rejects the proposal, the players settle their dispute through fighting and obtain payoffs from a war. To model war in a way that allows us to take comparative statics, assume that there is a differentiable function $w_i : \Theta \to R$, $i = A, B$, that determines the benefit of war for country i as a function of the parameter $\theta \in \Theta$, where θ represents changes in war-fighting technology. We also assume that countries pay a cost to fight a war $c_i > 0$.

If the war costs of country B are known to A, then it is also well known that this take-it-or-leave-it bargaining game has a unique subgame perfect equilibrium, and war occurs with a probability of zero if war is inefficient. In this unique equilibrium the settlement will occur at the value x_A such that $u_B(1-x_A)=w_B(\theta)-c_B$. As war payoffs change in a manner that hurts *B, A*'s share in the peaceful settlement increases.

Now assume that *A* faces uncertainty about *B*'s type c_B and, therefore, uncertainty about *B*'s cost of war. For simplicity we assume the set of types *T* is a compact interval and that *A* treats c_B as a random variable drawn from a distribution $F(c_B)$ with continuous density $f(c_B)$ on *T*.

Results

The characterization of a perfect Bayesian equilibrium to the take-it-or-leave-it bargaining game in which the risk of war is well known and presented here for reference.

Proposition 1 *Suppose* $f(c_B)/(1-F(c_B))$ *is increasing, then the bargaining game has a generically unique Perfect Bayesian Nash Equilibrium. Country B accepts if and only if* $w_B(\theta)-c_B \leq u_B(1-x)$. *If for* $x^*=u_B^{-1}(w_B(\theta))$ *the following inequality, holds* $\frac{u_A'(x^*)}{(u_A(x^*)+c_A-w_A(\theta))u_B'(1-x^*)}<f(0)$ *country A proposes* x^* *and there is no risk of war; otherwise, A offers* x^* *implicitly defined by the condition*

$$\begin{aligned}&\frac{u_A'(x^*)}{(u_A(x^*)+c_A-w_A(\theta))u_B'(1-x^*)}\\&=\frac{f(w_B(\theta)-u_B(1-x^*))}{(1-F(w_B(\theta)-u_B(1-x^*)))}\end{aligned}\tag{1}$$

and there is a positive probability of war.

The proof of this result appears in the Appendix, but is well known. Any omitted proofs for results below can also be found in the Appendix. The basic intuition is that for any proposal that give both players shares at least as high as their lowest war payoff, there is a risk-reward tradeoff for the proposer. Each increasing increment of a demand makes a peaceful settlement more valuable to the proposer but makes country *B* less likely to accept it *ex ante*. An optimal demand weighs these costs and benefits and puts them in balance.

To simplify the presentation as we consider changes in war payoffs, let $\gamma(x_A)=\frac{u_A'(x_A)}{u_B'(1-x_A)}$ and let $I_B^*(\theta)=w_B(\theta)-u_B(1-x^*(\theta))$ denote the equilibrium cut-point for country *B*. Thus $I_B^*(\theta)$ is the cost type of country *B* that is indifferent between war and peace at $x_A^*(\theta)$ given the variable θ.

We can now model the effect of an intervention that influences θ as a change to the payoffs from war. Our first proposition is a characterization of the effect of changing the war payoffs on the probability of conflict.

Proposition 2 *For a model with parameter* θ *and a Perfect Bayesian Equilibrium with interior* $x^*(\theta)$, *if* $\pi(\theta)=\Pr(\text{war}\mid\theta)>0$, *then the derivative* $\pi'(\theta)$ *exists and has the same sign as*

$$\frac{f[I_B^*(\theta)]u_B'(1-x_A)(\gamma(x_A)+\frac{w_{A'}(\theta)}{w_{B'}(\theta)})-(1-F[I_B^*(\theta)])\gamma'(x_A)}{f'[I_B^*(\theta)](w_A(\theta)-c_A-u_A(x_A))u_B'(1-x_A)-f[I_B^*(\theta)](2\gamma(x_A)u_B'(1-x_A))+(1-F[I_B^*(\theta)])\gamma'(x_A)}$$

The proof of this result is in the Appendix.

While this condition provides a complete characterization of the effect of changing war payoffs on the probability of conflict, some important cases deserve special attention. Consider the case with risk-neutral countries and war payoffs that are costly lotteries. We then have the following corollary.

Corollary 1 *In the standard take-it-or-leave-it bargaining model with risk-neutral countries,* $w_A(p)-c_A=p-c_A$ *and* $w_B(p)-c_B=1-p-c_B$. *If the equilibrium offer* x_A^* *induces a positive probability of war, then small changes in p do not affect the equilibrium probability of war. That is,* $\frac{d\pi}{dp}(p)=0$.

In other words, when the optimal offer has some chance of war, players are risk neutral, and the only variable we change is the probability of victory for *A*; then local changes in the distribution of military capabilities have no effect on the probability of war. This is what is conventionally understood as the neutrality result, but, as we show below, neutrality also holds under other conditions as well. In the bargaining process, *A*'s increased hawkishness as a consequence of a growing probability of victory is completely offset by *B*'s increased dovishness and willingness to settle. This makes sense when one thinks about what it means to be risk neutral. That is, the probability of winning the entire prize is assessed in the same way as a commensurate share of *X*. But as we see above, getting the offsetting forces is more complicated and really depends on the nature of both players' conflict payoffs and their utilities for peaceful settlements. This result is quite special because it requires the rates of change of war payoffs and the rates of change of utilities exactly to offset.

Another important case is when countries are risk averse. When the distribution of costs satisfy a technical condition, we can determine exactly the effect of changing the war payoffs on the probability of bargaining breakdown. Consider the following example where the two countries have risk-averse utilities, meaning that for every risky lottery that can result in winning or losing, there is a risk-free proposal that they prefer. In one such situation, when the pie is split $(x,1-x)$, it yields payoffs of to countries *A* and *B*, respectively. We will keep everything else as in the standard model and assume that the war payoffs are just $p-c_A$ and $1-p-c_B$ as in the canonical specification. Finally, assume that c_B is uniform on the unit interval.

The probability of war in this case is given by the expression

$$1-p-\frac{1}{4}2^{\frac{1}{2}}[c_A^2-c_A(c_A^2+8)^{\frac{1}{2}}+4]^{\frac{1}{2}}, \qquad (2)$$

which is linearly decreasing in p.[2] Thus, as A is made stronger, the likelihood of war decreases.[3] The following corollary gives some sufficient conditions.

Corollary 2 *Suppose that* $f'(I_B^*(\theta))\geqslant 0$, $u_i(\cdot)$ *is concave,* $w_A(p)=p-c_A$, $w_B(p)=1-p-c_B$, *and* $u_A(x)=u_B(x)$, *then increasing* p *decreases the probability of war if* $x^*(p)<1/2$.

This corollary says that increases in p decrease the probability of war when such a shift in the distribution of power benefits the country that is disadvantaged in the equilibrium peaceful settlement. The technical condition that $f'(I_B^*(\theta))\geqslant 0$ is satisfied if countries believe types with higher costs, such that they wish to avoid war, are more prevalent than countries with lower costs. That is, war is generally undesirable for most countries.

Finally we note that the corollary has a somewhat surprising welfare implication. Suppose we wanted to maximize the welfare of the states by thinking about interventions that change the distribution of power in war payoffs. If war is always more wasteful than a settlement, as is often assumed by scholars of international relations, then welfare is decreasing in the probability of war. Thus interventions that induce country A to make higher demands can actually be efficiency enhancing by reducing the probability of war.[4]

Remark 1 *Suppose* $u_A(x)+u_B(1-x)>1-(c_A+c_B)$ *for all x and costs* $c_i>0$*, then social welfare is decreasing in the equilibrium probability of war and thus by Corollary 2 welfare is increasing in p when* $x^*(p)\leqslant\frac{1}{2}$.

This remark shows how it can be the case that intervening on behalf of country A when A is already disadvantaged in the settlement is welfare improving. For example, in the case where the countries' utilities for consuming an amount x_i of the resources is $\sqrt{x_i}$ and war payoffs are $p-c_A$ and $1-p-c_B$, then intervening to help side A has both the effect of increasing A's share of the settlement and decreasing the probability of war. Thus, the intervention increases social welfare.

Risk-neutrality

Some have attributed the neutralizing effect of bargaining to the assumption that players are risk neutral in a common formulation of the bargaining model of war. Our result shows it is not risk neutrality but rather the assumption that changes in one player's payoffs exactly offset changes in the other player's payoffs at equilibrium that drives the result. In other words, the nature and scale of the neutralizing effect of negotiations is not the result of a particular player's utility. Rather, it is a result of a joint condition on the preferences of the two bargainers.

To see this, first consider the case where war payoffs are determined by a contest function and countries have risk neutral preferences over lotteries. Let

$$w_A(\theta)=\frac{\theta e_A^*}{\theta e_A^*+e_B^*}-\kappa e_A^*$$

$$w_B(\theta)=\frac{e_B^*}{\theta e_A^*+e_B^*}-\kappa e_B^*$$

where e_i^* is i's equilibrium effort in the contest, κ is the cost of effort, and θ is a force multiplier for country A. Substituting the optimal e_i^* produces a probability of winning for each county

$$p_A(\theta)=\frac{\theta^2}{(1+\theta)^2}$$

$$p_B(\theta)=\frac{1}{(1+\theta)^2}.$$

Clearly, the war payoff for country A is increasing and the war payoff for country B is decreasing in θ. Using the example where the war cost of country B is distributed uniformly on the unit interval, it follows from the proof of Proposition 2 that the probability of war is decreasing in θ if $\theta<1$ and increasing in θ if $\theta>1$, even though both countries have risk-neutral preferences over war lotteries. We can, therefore, conclude that risk neutrality is not sufficient for bargaining to neutralize the effect of changes in the distribution of war payoffs.

We can also show that risk neutrality is not necessary for bargaining to neutralize the effect of changes in the distribution of power on the probability of war. For example, let $w_A(\theta)$ be any increasing differentiable probability-of-winning function and suppose that $w_B(\theta)=1-w_A(\theta)$. Also assume that there is an increasing utility function for shares of the good and for each player:

$$u_A(x)=v(x)$$

$$u_B(1-x)=v(1-x).$$

Finally, select $F(c_B)=c_B$, let $u''(1/2)=0$, and $c_A=2w_A(\theta)$. In this case, the solution to the first-order condition is $x^*(\theta)=\frac{1}{2}$.

Using the characterization in Proposition 2, we know that the change in the probability of war is zero if $\gamma'(x^*(\theta))=0$ and $\frac{u'_A(x^*)}{u'_B(1-x^*)}+\frac{w'_A(\theta)}{w'_B(\theta)}=0$. With this example, $u''(1/2)=0$ implies $\gamma'(x^*(\theta))=0$ and $F(c_B)=c_B, c_A=2w_A(\theta)$ $\frac{u'_A(x^*)}{u'_B(1-x^*)}+\frac{w'_A(\theta)}{w'_B(\theta)}=0$. Thus, with non-linear share utilities for both actors we can still have the the equilibrium probability of war unchanged as a result of bargaining, and risk neutrality is not necessary.

Conclusion

Although the crisis bargaining game developed in Fearon (1995) has been influential in theories of war, there has been little work exploring the effect of changing war payoffs in situations with asymmetric information. We show that in some cases the strategic adjustment of offers offsets the strategic adjustment of the other states' willingness to accept settlements. But in other cases this is not true. Our first result fully characterizes when the two competing forces on the probability of war will cancel out, and it provides a characterization of the change in war probability as a function of the primitives. Our analysis also leads to some new results. For example, net of costs, if the change in A's war payoff equals the negative of the change in country B's war payoff and countries are risk averse, then whenever the equilibrium settlement favors country B, interventions that improve the unfavored country A's war payoff decrease the probability of war even though A's demands become more aggressive. Additionally, interventions may be welfare enhancing. Improving the war-fighting capability of a disadvantaged country might increase that country's peace settlement while also decreasing the probability of wasteful war fighting for both sides. Furthermore, we see how common simplifying assumptions, like risk neutrality and modeling war as a costly lottery, can have wide ranging effects for substantive implications and hypotheses. Therefore, it is important to know what determines the effect of changes in the distribution of power on the probability of war in the most important and widely used models.

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Supplementary material

The supplementary files are available at http://rap.sagepub.com/content/3/3

Notes

1. This assessment was made by Fearon (1993) and persists in the literature (Kydd, 2010).
2. Note that in this example the probability of war is decreasing in p even when the proposer is advantaged. This is not always, or, generally, the case. Proposition 2 can be used to show that in most interesting circumstances with risk-averse countries, the probability of war is increasing as p becomes greater than 1/2.
3. In this specification, the equilibrium offer solves a second-order polynomial. The solution is thus found in closed form, but is not worth reproducing here. Once the appropriate root is substituted into the probability of war function and simplified, the above expression.
4. Powell (1996) develops a model in which neutrality fails. In Powell's treatment, changes to the balance of power influence the probability that the proposer finds herself in a strategic setting where she wants to make an offer that involves risk. In the Powell model, $u_i(t) = t$, $w_1(p) = p - c_A$, and $w_2(p) = 1 - p - c_2$. If we differentiate the relevant functions and evaluate them as required, then Corollary 1's neutrality condition is satisfied. In fact, substituting the solution in Powell (1996: 266) for the optimal offer into the probability of war function, then whenever x^* is greater than the status quo, the probability of war is $(1 - c_2)/2$, which is not a function of p. In Powell, the non-trivial balance of power effects stem from the fact that changes in the balance of power alter the probability that the status quo is sufficient to result in a setting which is strategically equivalent to the ultimatum game. The balance of power effect does not stem from direct changes to the aggressiveness of either player conditional on them facing a non-trivial bargaining problem (and thus a risky offer being made).

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