Winningness in War and State Power

Jeremy Kedziora

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Abstract

I argue that state power cannot be divorced from the outcomes that it is meant to achieve. It follows from this that power can be conceptualized as the value of the outside option of the use of force in a bargaining game prior to war. In order to measure state power, I propose a generalization of the Bradley-Terry model for paired contests; the model allows for coalitions of states to pair against one another in contests (wars) that result in either wins, losses, or draws. I then embed this extension within a simple random utility setup that models selection explicitly. I apply the technique to measure the causes of state power over the last two centuries. Preliminary results indicate that regime type, but not necessarily military strength, determines state power.

1 Introduction

If politics is the process by which an authoritative distribution of resources is determined, then underlying any discussion of it must be some notion of power. This has been true of international relations beginning with one of the first identifiable modern analyses of international relations, Machiavelli's *The Prince*, continuing with the first articulation of the realist school in Morgenthau's 1948 classic *Politics Among Nations* and even forming a key component of the dialogue of our subfield into the present.

From the theoretical perspective, power is used by Morgenthau to define state *interest* (i.e. preferences, that which a state pursues); it has an application, and hence a definition, that is straightfoward - *the ability to convince agents to do what they otherwise would not*.[1] This sort of power may manifest itself simply through influence (Nye 2004 for example), or perhaps through leveraged violence or the threat of it (Schelling, 1960, 1966). While this definition is conceptually straightforward, translating it into empirical observables has been anything but. Thus, Waltz (1979) narrows Morgenthau's understanding of power considerably, focusing exclusively on the material capabilities of states in the context of his systemic theory of international relations. This focus on material capabilities of states has motivated empirical investigation, both with respect to the questions asked and the measures of power employed (See, among others, Singer et. al. 1972).

What has been neglected in the wake of focusing on exclusively on material capabilities as a measure of state power is the extent to which that focus adequately captures our original sparse definition of power. Thus, this paper is an attempt to consider this question rigorously, and link more closely theoretical understandings of power with empirical measurement and operationalization of it. Taking a cue from the theoretical literature on crisis bargaining and war initiation, I suggest treating power as a latent variable to be estimated from the data available.

Thus, states possess power to varying degrees as a function of the underlying determinants of power, whose effect on it are quantities to be estimated. As with other related data driven approaches to the measurement of power, the approach I will present below separates the determinants of power from the particular theoretical understanding of power in international relations that I will articulate below, and thus allows the researcher to draw inferences about the *causes* of power.

A Definition of Power

Traditional realist thought has focused on power as manifested through material indices of states while neglecting the use of it as an exercise in actual or implied coercion. As an example, one need look no further than Waltz's (1979) attempt to count "poles":

> A systems theory requires one to define structures partly by the distribution of capabilities across units. States, because they are in a self-help system, have to use their combined capabilities in order to serve their interests. The economic, military,

[1] See also Dahl (1957) for a definition of power along these lines.

> and other capabilities of nations cannot be sectored and separately weighted. States are not placed in the top rank because they excel in one way or another. Their rank depends on how they score on *all* of the following items: size of population and territory, resource endowment, economic capability, military strength, political stability and competence... Ranking states, however, does not require predicting their success in war or in other endeavors. We need only rank them roughly by capability.[2]

Mearsheimer is even more explicit in his identification of power and capabilities, arguing that it makes more sense to measure power via material assets rather than outcomes.[3] His principle objection is that a focus exclusively on outcomes makes it extremely difficult to relate ends (outcomes) to the means used to achieve them (power).[4] Yet if power has nothing to do with outcomes at all, it is equally difficult to relate the two. Divorcing power from outcomes entirely implies that power has no ability to yield favorable ends, and so no place as means in international relations.

In contrast with conceptions of power that depend upon material indices, I argue that the recent formal literature on the outbreak of war during crisis bargaining suggests that power, in Dahl's sense, and outcomes, at least in the arena of war, ought to be fundamentally related to one another, though *not* equated.

Fearon (1995), following Bueno de Mesquita (1981), was among the first to explore the strategic aspects of crisis bargaining and war. He concentrates primarily on the conditions under which there will exist a peaceful settlement preferable to war for both parties involved in the crisis. Others (Powell 1993, Wagner 2000) have considered richer bargaining environments. In the former, Rubinstein's canonical model of bilateral bargaining is extended to allow each side to impose a solution at some cost, while in the latter, total war functions in an analogous way.[5] In essence, in models of crisis bargaining, war acts as an *outside option*; if states are unable to come to an agreement that satisfies both sides, then they may choose to impose an expected solution to the bargaining problem, i.e. resort to war.

In general treatments of bargaining with impatient actors (i.e. the delay associated with continued bargaining is costly), the addition of an outside option in this way has the effect of bounding below the value of the agreement for both participants; if there is a peaceful settlement available, then it must be at least as good, for all involved agents, as taking the outside option and imposing a solution.[6] Thus, if we take seriously the models of crisis bargaining that purport to explain why war breaks out, then it follows that we can equate *skill in war* with a kind of bargaining power. States that are expected, *a priori*, to be likely to win the wars in which they engage will be able to extract more from their prospective opponents at the negotiating table during the crisis prior to war, as their outside option will be relatively more attractive.[7]

This relates nicely to the original understanding of power articulated by Morgenthau and Dahl. I assume, without much worry, that states would prefer to "win" the crises in which they participate rather than "lose" them, whether this involves extracting more resources/territory from an opponent, or implementing a policy closer to one's ideal point. To the extent that the states involved in a crisis have strictly opposed preferences over the available settlements, it follows that when one state obtains a relatively better settlement, the other state obtains one that is relatively worse.[8] Therefore, extracting a better settlement to a crisis is, under these circumstances, is exactly convincing an agent to do what they would otherwise not.

Thus, to the extent that war acts as an outside option in crisis bargaining, skill in war acts as a form of bargaining power, and can be leveraged against an opponent as an implicit threat to convince them to do what they otherwise would not, i.e. yield in a confrontation

[2] Waltz (1979), p. 131.

[3] Mearsheimer (2001), p. 56,60.

[4] See the discussion on page 60. "...one of the most interesting aspects of international relations is how power, which is a means, affects political outcomes, which are ends." He also suggests that this conception of power leads to implausible conclusions; this objection largely stems from the fact that he has already accepted material indices as his definition of power. That is, it is implausible that Russia was more powerful than France in 1812 only because Mearsheimer has decided *a priori* that what is relevant in determining power favored France.

[5] See also Muthoo (1999) for a review of bargaining models.

[6] See Muthoo (1999) on this.

[7] There is, of course, another aspect to this. If we take these models of crisis bargaining seriously, then it is also true that incomplete information results in wars by obscuring the attractiveness of war as an outside option. Thus, credible information revelation is also a source of power. Since I do not have data on this, and it is not even clear what kind of data would adequately measure such an abstract concept, I choose to focus on outcomes in war, rather than outcomes of militarized inter-state disputes.

[8] While there are clearly many circumstances in which the status quo is Pareto-dominated by one or more existing alternatives, most models of crisis bargaining stipulate preferences of this sort. Also, one has to question the use of the word "crisis" to describe a situation if there are outcomes that both states would prefer to the current status quo.

and sacrifice their interests. Since skill in war implies that victory is more likely, this suggests that the power to influence the outcome of a crisis that is resolved short of war favorably depends crucially on the expected *outcome* in war. This brings us full circle to the concern I suggested at the beginning, namely that the restriction to capabilities favored by Waltz and Mearsheimer, among others, does not necessarily tap into this sort of bargaining power, a fact both note.

The foregoing discussion implies that state ability, which I shall call winningness, in war is related to bargaining power at the negotiating table during an international crisis. This conceptualization is beneficial in that it relates ends and means in the definition of state power coherently, and grounds power explicitly in the theoretical literature on crisis bargaining. Since the main concern here is an empirical one, in particular the desire to infer the effect of material capabilities on state power, the lesson to take away from the brief, casual discussion of the insights from the theoretical literature I presented above is that we require a technique which:

- Treats winningness in war as an *actor-specific latent quantity* to be estimated
- Incorporates the *effects of covariates* on said latent quantity
- Allows for *explicit comparisons between agents* via a ranking.
- Allows the researcher to make statements about the uncertainty in power.

Formulation of such a modeling technique and subsequent estimation would allow us to explicitly relate capabilities to winningness in war, so linking means and ends. To the extent that the discussion of the bargaining literature given above holds, this suggests that such a technique would be able to tap into state bargaining power during crisis negotiation, and so evaluate the extent to which capabilities are related to the definition of power given at the outset.

2 A Model with Coalitions and Ties

In this section, I specify a model that will allow us to estimate state winningness in war; the estimator I present here is not new. It is, in fact, a variant of the Bradley-Terry (1952) model for paired comparisons. The approach taken to modeling paired comparisons by Bradley and Terry has been widely applied in areas as diverse as taste-testing (Baker et. al. 1960, Berg et. al. 1955, and Bliss et. al. 1956), chess ranking (Good, 1955) sports (Goodman, 1970, Agresti, 2002), economics, machine learning, and very recently, political science (Spirling 2008, Spirling and Carter 2008). Denote the set of agents engaging in contests with one another by $N = \{1, 2, \ldots, n\}$. Then the usual Bradley Terry formulation assumes that for any $i, j \in N$, if i and j meet in a contest:

$$\begin{aligned} \text{logit } \{p(i \text{ defeats } j)\} &= \pi_i - \pi_j \\ p(i \text{ defeats } j) &= \frac{\exp\{\pi_i\}}{\exp\{\pi_i\} + \exp\{\pi_j\}} \end{aligned} \quad (1)$$

The parameters π_i and π_j are assumed to be latent individual ability parameters associated with each potential contestant.

The available data (on which more to come) for wars between states has some similarity to the data structure implicitly underlying the paired comparison model above in the sense that states explicitly meet for a contest from which may emerge a winner and loser.[9] At the same time, a non-trivial number of the militarized interstate disputes during the last 200 years involved a coalition of actors on at least one side, while nearly 36 percent of wars involved coalitions of actors.

The implication of this is that, if we treat the wars as series of individual dyadic contests, there is likely to be a considerable amount of dependence across the observations. That is, it is very difficult to believe that it is appropriate to treat the Great War dyad containing Germany and France as independent of the Great War dyad containing Germany and Great Britain - victory or defeat for one likely implies victory or defeat for the other.[10] It is much more reasonable to assume that, conditional on the winningness in war of the participant states, the outcome of World War II and the Crimean War are independent of one another.

One way of dealing with this dependence is to treat the *coalitions* themselves as the objects engaging in con-

[9]Outcomes in war are, after all, an obvious method of judging the underlying latent ability - winningness in war - of states. Once a judgement has been made by the involved parties, it is not even necessary to fight the war to its expected conclusion, a point made by Slantchev (2003) and Goemans (2000), perhaps one reason why war outcomes are often limited.

[10]Although it is certainly true that Germany defeated Russia in the Great War and was subsequently herself defeated, while defeat of France in World War 2 did not imply defeat of Britain. It is also true that the exhaustion of the Austro-Hungarian empire in the Great War left Germany with few options besides surrendor.

tests with one another. Since dealing explicitly with coalitions makes the latter, but not the former assumption of the previous paragraph, it has the benefit of ameliorating to some degree the issue of dependence across observations that would be present in dyadic data. Each war in the dataset thus constitutes a single observation.

As this suggests, taking this approach is not without its drawbacks; for example, we will lose some information in the sense that individual campaigns are aggregated into events of a larger scale. However, this information loss is simply the realization of the fact that the data contain less information than a dyadic treatment would suggest. Thus, despite this, on the balance, it seems that we gain more from addressing the potentially pernicious effects of dependence than we lose from aggregating the data. I will follow Huang et al. (2006) in applying a generalized model for paired comparisons among coalitions.

As before, N will denote individual agents, here states. At any time, two subsets of N may form into coalitions and fight each other in a war; for the k^{th} observation, denote these coalitions by $\mathcal{C}_A^k, \mathcal{C}_B^k \subsetneq N$ such that $\mathcal{C}_A^k \neq \emptyset, \mathcal{C}_B^k \neq \emptyset$ and $\mathcal{C}_A^k \bigcap \mathcal{C}_B^k = \emptyset$. If we assume war to be such that, conditional on individual state abilities, each member of a given coalition is equally important with respect to determining the outcome of the fighting, then this leads to the following analogue to (1):

$$p(\mathcal{C}_A^k \text{ beats } \mathcal{C}_B^k) = \frac{\sum_{i\in\mathcal{C}_A^k} \exp\{\pi_i\}}{\sum_{i\in\mathcal{C}_A^k} \exp\{\pi_i\} + \sum_{i\in\mathcal{C}_B^k} \exp\{\pi_i\}}$$

In addition to modeling coalitional strength explicitly, wars may end in stalemate, with neither side able to decisively defeat the other on the field. Thus, I follow Davidson (1970) in modeling the prospect that two coalitions will end their war in a tie. The probability of a tie will be proportional to the geometric mean of ability:

$$\theta\sqrt{\sum_{i\in\mathcal{C}_A^k} \exp\{\pi_i\} \sum_{i\in\mathcal{C}_B^k} \exp\{\pi_i\}} \qquad (2)$$

where $\theta \geq 0$ is a constant of proportionality which does not depend upon characteristics of members of $\mathcal{C}_A^k$ and $\mathcal{C}_B^k$, though may in general depend upon the war itself (terrain, for example). Intuitively, making the assumption that (2) holds means that that the probability of a tie in war is dependent upon the extent to which the pair of coalitions are distinguishable in their underlying levels of ability.[11] Under this parametric assumption, the probability of a tie will be largest when the underlying abilities of the coalitions are very similar.

With this allowance for ties in war, $p(\mathcal{C}_A^k$ defeats $\mathcal{C}_B^k)$ is:

$$\frac{\sum_{i\in\mathcal{C}_A^k} \exp\{\pi_i\}}{\sum_{i\in\mathcal{C}_A^k} \exp\{\pi_i\} + \sum_{i\in\mathcal{C}_B^k} \exp\{\pi_i\} + \theta\sqrt{G}}$$

where:

$$G = \left(\sum_{i\in\mathcal{C}_A^k} \exp\{\pi_i\}\right)\left(\sum_{i\in\mathcal{C}_B^k} \exp\{\pi_i\}\right)$$

Similarly, the probability of a tie $p(\mathcal{C}_A^k$ ties $\mathcal{C}_B^k)$ is:

$$\frac{\theta\sqrt{G}}{\sum_{i\in\mathcal{C}_A^k} \exp\{\pi_i\} + \sum_{i\in\mathcal{C}_B^k} \exp\{\pi_i\} + \theta\sqrt{G}}$$

Selection

While the simplicity of the model specified above is appealing, one potential problem is that if researchers can infer the effect of these variables on outcomes in war, then perhaps the rulers of states contemplating participation in these wars can also infer these effects. To the extent that states would prefer to win wars rather than lose them, the implication is that states will only participate in wars which they anticipate will end favorably for them. That is, we may have an issue of sample selection, leading us to mistakenly suspect that material capabilities are irrelevant in determining war outcomes, for example.

To deal with this potential problem, I embed the generalized Bradley-Terry model within a simple choice model in which an initiator state involved in a militarized interstate dispute determines whether to initiate a war or not. Underlying this choice framework is the assumption that each potential initiator has complete information about the coalition formation process that will ultimately yield the coalitions involved in the war, for example, anticipating the equilibrium path of play in a subgame perfect equilibrium. Then in the standard random utility framework, the probability that a given

[11]Assuming that the choice axiom of Luce (1959) holds. See Davidson (1970), p. 319, for the original development of this extension. The conceptualization of decisiveness as dependent upon a threshold level of difference between states is analogous to Rao and Kupper (1967).

state i chooses war is:

$$p\left(E(u_i(W)) + \varepsilon_i(W) \geq u_i(P) + \varepsilon_i(P)\right)$$

where $\varepsilon_i(\cdot)$ is a preference shock, unobserved to the analyst, $u_i(W)$ and $u_i(P)$ are the utilities associated with war and peace respectively, and choosing war entails an expected utility calculation:

$$\begin{aligned} E(u_i(W)) &= p(\mathcal{C}_A \text{ defeats } \mathcal{C}_B \mid i \in \mathcal{C}_A)u_i(V) \\ &\quad + p(\mathcal{C}_A \text{ ties } \mathcal{C}_B)u_i(T) \\ &\quad + p(\mathcal{C}_B \text{ defeats } \mathcal{C}_A \mid i \in \mathcal{C}_A)u_i(D) \end{aligned}$$

where V, T, and D are outcomes associated with a victory, tie, and defeat, respectively. The probabilities in the previous expression are simply those from the Bradley-Terry coalitional model that I have analyzed above. Assuming $\varepsilon_i(\cdot)$ is distributed Type-1 Extreme Value, this would yield a simple logit choice model where:

$$\begin{aligned} p(i \text{ chooses } W) &= \frac{\exp\{E(u_i(W))\}}{\exp\{E(u_i(W))\} + \exp\{u_i(P)\}} \\ p(i \text{ chooses } P) &= \frac{\exp\{u_i(P)\}}{\exp\{E(u_i(W))\} + \exp\{u_i(P)\}} \end{aligned}$$

The outcomes are then peace, victory, tie, or defeat in war, and if the outcomes of each war are assumed to be independent of one another, then we may write the likelihood for K observations in the usual way:

$$\begin{aligned} \mathcal{L}(\pi \mid y) = \prod_{k=1}^{K} & \left\{p(i_k \text{ chooses } W)p(\mathcal{C}_A^k \text{ defeats } \mathcal{C}_B^k)\right\}^{y_{AB}^k} \\ & \times \left\{p(i_k \text{ chooses } W)p(\mathcal{C}_B^k \text{ defeats } \mathcal{C}_A^k)\right\}^{y_{BA}^k} \\ & \times \left\{p(i_k \text{ chooses } W)p(\mathcal{C}_A^k \text{ ties } \mathcal{C}_B^k)\right\}^{y_t^k} \\ & \times \{p(i_k \text{ chooses } P)\}^{y_P^k} \end{aligned}$$

where y_{AB}^k is an indicator variable taking a value of 1 where $\mathcal{C}_A^k$ defeats $\mathcal{C}_B^k$ and a zero otherwise, and y_t^k and y_P^k indicates a tie and the choice of peace in the same way. This likelihood may then be dealt with using either maximum likelihood or Bayesian simulation.

In what follows, I will adopt a Bayesian approach to fitting the model. The priors on parameters will be simple diffuse normal distributions, $\mathcal{N}(0, 100)$, yielding a posterior probability for the ability parameters π of:

$$p(\pi \mid y) \quad \propto \quad \prod_{i \in N} N(\pi_i \mid 0, 100)\mathcal{L}(\pi \mid y)$$

This does not represent an ideological commitment to Bayesianism, but rather a pragmatic consideration; the model is computationally easier to evaluate via simulation using a simple Metropolis-Hastings algorithm with a normal jumping distribution (to avoid an improper posterior) than by directly optimizing the likelihood in the classical framework.[12]

Structured Estimation

The researcher has, at this point, two paths on which to proceed with estimation. Somewhat akin to a fixed effect, with a suitable identification restriction, one could estimate an ability parameter π_i for each state $i \in N$. This approach, unstructured estimation, would yield a rank ordering (notice that the nature of the estimator implies that ability is transitive) of the winningness of states in war. The interpretation of such a result would then be simple: the greater a state's winningness in war, the more coercive power it has relative to the remaining states.

This sort of unstructured estimation, while perhaps appropriate in other settings, is problematic here for at least two related reasons. In the first place, to pursue an unstructured estimation of this sort is to make the assumption that the winningness in war of a state is an intrinsic quality of that state. This cuts against the grain of common intuition that states are powerful *because* of the capabilities and influence they wield, qualities that may come and go. Hence the second reason: an intrinsic quality is by definition a constant one across time and circumstance. Despite this, empires rise and fall, states rise to the ranks of the great powers and just as quickly leave them behind, and the tools of war change; the effectiveness of the mounted French knights whose charge carried all before it prior to the 14^{th} century was shaken at Crecy (1346) and Agincourt (1415), and obliterated at Pavia (1525). Similarly, it remains an open and interesting question what changes nuclear arsenals have wrought in warfare.

Thus, while modeling winningness in war as an intrinsic quality may be a reasonable approximation to reality in the short term, war is an endemic feature of human society, and the analysis I present here will span 200 years, during which the *Pax Britannica* was replaced with the *Pax Americana*. This suggests that winningness

[12] In particular, the data needs to be restructured with each evaluation of the likelihood, necessitating the use of C++ to complete the computations in a reasonable amount of time; Bayesian simulation is easier to code up from scratch in such an environment than Newton methods for optimization.

in war, and more broadly, power, is dynamic and therefore not an intrinsic feature of states. More generally, winningness in war, and hence state power, cannot be meaningfully separated from its causes in the present analysis.

Alternatively, we may parameterize the ability parameters themselves in terms of regressors and estimate the effect of covariates on winningness of states in war. A typical formulation would be one in which ability in war is simply a linear combination of the covariates associated with i, $x_i = \{x_i^1, \ldots, x_i^M\}$:

$$\pi_i(x_i) \quad = \quad \sum_{m=1}^{M} x_i^m \beta_m$$

Here, winningness is war is explicitly related to and modeled by its causes to the extent that the covariates capture those causes. Since the covariates may vary with time, we can model the dynamic nature of winningness in war. Unfortunately, utilizing covariates still does not address the fact that the tools of war themselves change; it seems that one could consider changes in the effectiveness of the tools of warfare by employing data at a finer level. A future version of this paper will make use of the CDB 90 battle-level data for this very purpose - to the extent that winning battles implies winning wars, this should contribute to an analysis of shifts in the tools of warfare. Despite this shortcoming, given the criticism I just advanced against the nondynamic nature of unstructured estimation, this route seems to be the more profitable one, and I will take it here.

3 Data and (Initial) Results

I evaluate the winningness of states in war using data from the Correlates of War on Interstate Wars.[13] The universe of cases that I consider here consists of all wars from 1816 to the present, as coded by the Correlates of War database, listed in Table 1. There are 79 such wars involving a total of 81 states, beginning with the Franco-Spanish war in the immediate aftermath of the Napoleonic Wars and ending with the coalitional war against Iraq in 1990. As I noted above, roughly 36% of these wars involved a coalition of states on at least one side, with the largest such coalition being that of the victorious allies in World War II with 22 members. Most (72 of 79) ended with a clear (though not unconditional) victory for one side, with the remainder ending in a tie. As noted in the discussion of the model, the agents whose abilities we would like to infer are individual states; coalitions consisting of those states engage one another in paired comparisons, i.e. wars.

Extent theories about why states win wars generally cite either the extent to which the state in question can bring material capabilities to bear on its opponent (Powell 1993, Slantchev 2005, and Stam 1996 are a few) or the type of the regime of the state (Reiter and Stam 1998a, Bennett and Stam 1998, Reiter and Stam 1998b, Horowitz et. al. 2005, Bueno de Mesquita et. al. 1999). The rationale for the former is obvious (more tanks and more soldiers implies more success in war), while the rationale for the latter is less so (see Bueno de Mesquita et. al. 1999 for a theoretical treatment that links the two), though some evidence suggests that armies of democratic states may fight with better logistics, initiative, and leadership (Reiter and Stam 1998a).

Political Effects

I break the models up into two categories; those variables that deal with regime characteristics and those variables that deal with material capabilities. Scholars have long noted that the war and warlike behavior varies systematically with regime type. Indeed, an entire cottage industry has sprung up around the analysis of the democratic peace. Increasing evidence also suggests that democracies are more likely to win the wars in which they engage, perhaps due to selection (Bueno de Mesquita et. al. 1999), resource mobilization (but see Kugler and Domke 1986), or individual motivation (Reiter and Stam, 1998a). Others have noted that democracies are particularly prone to defend themselves vigorously if attacked, as Japan found to its consternation 1941-1945, while democratic aggressors may be ambivalent in their pursuit of victory in war.

The first model I present includes `Initiator`, a dummy variable indicating that the state in question initiated hostilities by attacking its opponent and `Polity`, the constructed measure of democracy available in the Polity IV data, with a constant parameterizing the probability of a tie in war, while the second interacts `Polity` with `Initiator` and then with `Target`, the latter a dummy variable indicating that the state in question was the target of an attacker in war. *A priori*, the expectation should be that states initiate hostilities when they have expectations that war will go in their favor; `Initiator` should have a positive effect

[13] Sarkees (2000). See also Singer et. al. (1972) and Small and Singer (1982).

Table 1: Inter-State Wars

Franco-Spanish (1823)	Russo-Turkish (1828)	Mexican-American (1846)
Austro-Sardinian (1848)	Schleswig-Holstein (1848)	Roman Republic (1849)
La Plata (1851)	Crimean (1853)	Anglo-Persian (1856)
Italian Unification (1859)	Spanish-Moroccan (1859)	Italo-Roman (1860)
Italo-Sicilian (1860)	Franco-Mexican (1862)	Ecuadorian-Columbian (1863)
Schleswig-Holstein (2) (1864)	Lopez (1864)	Spanish-Chilean (1865)
Seven Weeks (1866)	Franco-Prussian (1870)	First Central American (1876)
Russo-Turkish (1877)	Pacific (1879)	Anglo-Egyptian (1882)
Sino-French (1884)	Second Central American (1885)	Franco-Thai (1893)
Sino-Japanese (1894)	Greco-Turkish (1897)	Spanish-American (1898)
Boxer Rebellion (1900)	Sino-Russian (1900)	Russo-Japanese (1904)
Third Central American (1906)	Fourth Central American (1907)	Spanish-Moroccan (1909)
Italo-Turkish (1911)	First Balkan (1912)	Second Balkan (1913)
World War I (1914)	Russo-Polish (1919)	Hungarian-Allies (1919)
Greco-Turkish (1919)	Franco-Turkish (1919)	Lithuanian-Polish (1920)
Sino-Soviet (1929)	Manchurian (1931)	Chaco (1932)
Saudi-Yemeni (1934)	Italo-Ethiopian (1935)	Sino-Japanese (1937)
Changkufeng (1938)	Nomonhan (1939)	World War II (1939)
Russo-Finnish (1939)	Franco-Thai (1940)	First Kashmir (1965)
Palestine (1948)	Korean (1950)	Russo-Hungarian (1956)
Sinai (1956)	Assam (1962)	Vietnamese (1965)
Second Kashmir (1965)	Six Day (1967)	Israeli-Egyptian (1969)
Football (1969)	Bangladesh (1971)	Yom Kippur (1973)
Turco-Cypriot (1974)	Vietnamese-Cambodian (1975)	Ethiopian-Somalian (1977)
Ugandan-Tanzanian (1978)	Sino-Vietnamese (1979)	Iran-Iraq (1980)
Falklands (1982)	Israeli-Syria (1982)	Sino-Vietnamese (1987)
Gulf War (1990)		

on winningness in war. Similar results should obtain for `Polity` if democracy is associated with victory.

To get a sense of the data, 88 states (not necessarily distinct) states were initiators in the wars in which they were involved. I plot a histogram of `Polity` in Figure 0. Most states involved in wars over the relevant time span were heavily autocratic, by the `Polity` measure. Missingness of the data was present in a small number of cases; I simply imputed the missing data via the `R` implementation of `amelia` provided by King et. al. (2001).

As I described above, Bayesian simulation was used to compute a posterior distribution over the parameter space. Assessment of convergence of the Markov chains to the stationary distribution during the simulation is always crucial prior to making any inferences regarding parameter distributions. To judge convergence, I employed Gelman and Rubin's (1992) $\widehat{R}$ statistic on three chains; these were judged to have converged after 15000 iterations of the algorithm (less the first thousand as burn-in). The actual $\widehat{R}$ statistics appear in Table 2; values close to 1 indicate convergence, although as with most of Bayesian inference, there is no explicit threshold value. In addition, I assess convergence graphically in Figure 1; the plots on the left are time series of the serially correlated draws from the posterior distribution for chain 1. Stationarity is suggestive of convergence.

The positive effects of `Initiator` and `Polity` on state winningness in war are evident from Table 2a, in which I list the posterior mean as the point estimate of parameter effect and the 95% region of highest posterior density, and Figure 1, in which I plot the posterior density in the right column.[14] The estimation sug-

[14]Note that here this means exactly what it does not in classical statistics; with 95% probability, the parameter (though we should

Figure 0. Polity Descriptive Histogram.

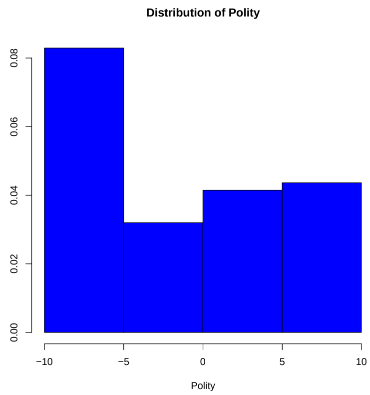


Table 2a: Structured Estimates: Political Variables

Coefficient	Posterior Mean	$\widehat{R}$
`Constant`	-2.1592 $[-3.1622, -1.3424]$	1.000
`Initiator`	1.0019 [0.5445, 1.4759]	1.000
`Polity`	0.0703 [0.0143, 0.1311]	1.000

Table 2a. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

Figure 1. Time Series of Posterior Draws, Table 2a.

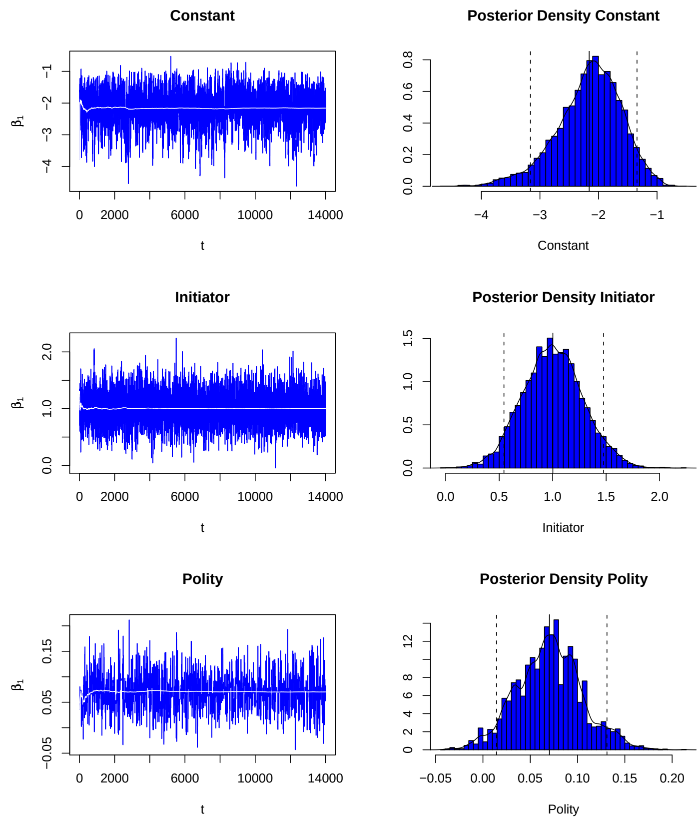


Figure 1. On the left are the time series of the draws from the posterior density. The white line plotted on each is the running mean of the draws as the simulation progress. On the right are the posterior densities for the first chain. The solid vertical line indicates the posterior mean, while the dashed vertical lines indicate the 95% region of highest posterior density.

gests that initiators have traditionally done well in their wars, which lends credence to the notion that states assess their future carefully before entering into war. In addition, being a liberal state is indeed a boon to winningness in war, with the vast majority of the posterior density larger than 0.

Given the status of `Polity` as a somewhat arbitrary aggregation of responses on a number of items, we might like to know a bit more about which of those underlying items actually reinforces state winningness in war. Taking into account Jackman and Trier's (2008) suggestion regarding dependence across the `Polity` items, I focus on the three of those within the `Polity` database that do not exhibit this problem:

- `Exrec`: an ordinal variable indicating the extent to which executive recruitment is free
- `Exconst`: an ordinal variable indicating the extent to which an executive is constrained
- `Polcomp`: an ordinal variable indicating the extent to which political competition is free

The distribution of these data are generally multimodal, with most states displaying either marked authoritarian tendencies or marked democratic tendencies (i.e. most weight is on the low and high ends of the scale).

Table 2b displays the results of the estimation associated with parameterizing winningness in war as a function of the Polity IV democracy indicators. In each case, almost all the posterior density is larger than 0; since the Polity IV items take on larger value for increased democratic tendencies, this suggests that in each cate-

be clear that here there is no true parameter) is in the 95% region of highest posterior density.

Table 2b: Structured Estimates: Polity IV Items

Coefficient	Mean	$\widehat{R}$
`Exrec`	0.1460	1.002
	$[-0.0096, 0.3054]$	
`Exconst`	0.1750	1.002
	$[0.0423, 0.3163]$	
`Polcomp`	0.1589	1.002
	$[0.04518, 0.2791]$	

Table 2b. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density. Convergence was evaluated as in Table 2a. Posterior densities were analogous to that for `Polity`, with an identifiable mode.

Table 3a: Structured Estimates: Political Variables

Coefficient	Posterior Mean	$\widehat{R}$
`Constant`	-2.0794	1.000
	$[-3.0296, -1.2685]$	
`Initiator`	0.7959	1.000
	$[0.2950, 1.3133]$	
`Polity*Initiator`	0.0158	1.001
	$[-0.2409, 0.2174]$	
`Polity*Target`	0.1346	1.000
	$[0.0544, 0.2162]$	

Table 3a. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

gory, liberal rules regarding executive recruitment, constraints on executive powers, and free political competition, more democracy is helpful in winning wars. Moreover, executive constraints are associated with the largest substantive effect of the three. This may reflect the argument made by North and Weingast (1989) regarding the advantages associated with constitutional commitment in securing the extractive capacity of the state during war; executives able to commit via constitutional constraints to repay the debts incurred by borrowing during war are said to be able to extract greater means during war.

In Table 3a, I display the results for `Polity` interacted with `Initiator` and `Target`; Figure 2 plots the time series of the draws and the posterior densities for each parameter. Examining the inferences drawn from the posterior distributions, we can see that, as before, initiators do well in war. Defending democrats also do quite well in wars, relative to their authoritarian counterparts. In each case, as the left column of Figure 2 suggests, the majority of the posterior distribution is larger than 0. In addition, as I had anticipated, democratic aggressors (of which the data contains more than a few), perform indifferently in war. This is unsurprising; democracies are unable to coerce their subjects to give up the means of violence effectively, and have little to compensate them with for a war waged for profit.[15]

[15] Others have argued that extensions of the franchise were a means to reward subjects are participating in the mass wars of the late 19th and early 20th century. See Ticchi and Vindigni (2006).

Thus, we can compute the probability that a democratic defender state (D) prevails in war against an autocratic aggressor (A), $p(D$ defeats A), as:

$$\frac{\exp\{\pi_D(x_D)\}}{\exp\{\pi_A(x_A)\} + \exp\{\pi_D(x_D)\} + \theta\sqrt{G}} \quad \approx \quad 0.57$$

and the probability of a tie, $p(D$ ties $A)$, as:

$$\frac{\theta\sqrt{G}}{\exp\{\pi_A(x_A)\} + \exp\{\pi_D(x_D)\} + \theta\sqrt{G}} \quad \approx \quad 0.06$$

where:

$$\begin{aligned}
\pi_D(x_D) &= 9 * 0.1346 \\
\pi_A(x_A) &= 0.7959 + 1 * 0.0158 \\
\theta &= \exp\{-2.0794\} \\
G &= \exp\{\pi_A(x_A)\}\exp\{\pi_D(x_D)\}
\end{aligned}$$

This corresponds roughly to the situation prevailing on the eve of the attack on America by Japan in 1941. Thus, with no other information, a model based entirely on the political variables would lead us to predict that America would have prevailed over Japan in war; of course, this leaves out the remaining information concerning the effect of aggregating over the entire Allied and Axis coalitions. Doing so does not meaningfully change the results. Analogous calculations, ag-

Figure 2. Time Series of Posterior Draws, Table 3a.

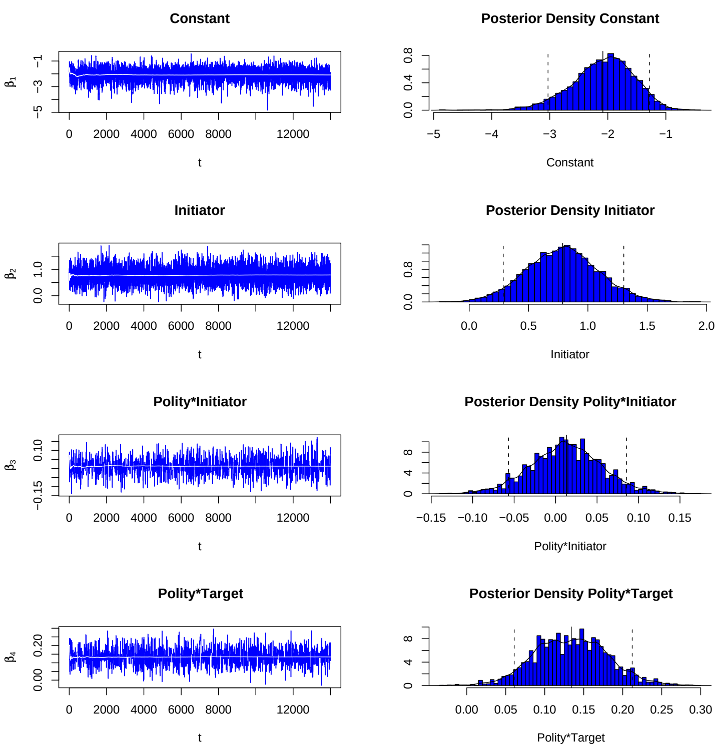


Figure 2. On the left are the time series of the draws from the posterior density. The white line plotted on each is the running mean of the draws as the simulation progress. On the right are the posterior densities for the first chain. The solid vertical line indicates the posterior mean, while the dashed vertical lines indicate the 95% region of highest posterior density.

gregating across the coalitions involved in the Great War, suggest that the Entente powers and their allies would have won the war with probability 0.768, tied with probability 0.047, and lost with probability 0.185.

Knowing little else about states, these results would suggest that liberal tendencies underlie state winningness in war, that autocrats are more likely to lose wars against democrats, and that there is some support for the arguments of North and Weingast who cite the credible commitment obtained by constitutionally constraints rulers as a key motivating factor in mobilizing the resources for war. Moreover, these results may be suggestive of the importance of public opinion in mobilizing support for war; democratic defenders are relatively more likely to prevail, perhaps because they have a stake in the political process which they are called upon to defend. Democratic aggressors perform indifferently.

Table 3b: Structured Estimates: Political Variables

Coefficient	Posterior Mean	$\widehat{R}$
`Constant`	-2.0887 [-3.0486, -1.2869]	1.000
`Initiator`	1.8445 [0.7935, 2.9167]	1.000
`Exconst*Initiator`	0.06007768 [-0.1280, 0.2605]	1.001
`Exconst*Target`	0.2989 [0.0941, 0.5018]	1.002

Table 3b. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

These results also extent to replacing `Polity` with the most substantively significant of the underlying items used to produce it, `Exconst`. I display the estimation results associated with this variable in Table 3b; the lesson of the table is that constrained executives defending their states against aggressors tend to win, while being an initiator remains an advantage in war. Convergence results and posterior densities were analogous to those displayed in Figure 2, and so I omit them. Finally, I would note that nearly identical results were also obtained replacing `Polity` with `Polcomp`, the free political participation item. These results suggest that 1) the more credibly rulers can commit not to take advantage of their subjects and 2) the more stake subjects have in the political process that characterizes the life of their state, the more likely the state is to prevail in a defensive war.

Material Effects

The next natural question for us to ask is whether these results obtain when we also analyze political variables in conjunction with traditional military capabilities variables. However, before I proceed to consider both in the same model, I first analyze military variables exclusively. Here, I will concentrate on the material capabilities catalogued by the Correlates of War National Material Capabilities database. Available information exists on both short term and long term (latent) factors that one might expect would influence winningness in war. The primary items available are:

- `Expend`: military expenditure
- `Personnel`: military personnel
- `IRST`: iron and steel production
- `Energy`: energy usage
- `Pop`: total state population
- `UPop`: total state urban population
- `CINC`: the average across the six items relative to the rest of the world

It seems logical to expect these indictors to help in war; at the very least, more troops and more money spent ought not hurt in war. What is less clear is the extent to which latent factors ought to affect winningness in war, the more so since most wars are short, limited affairs; rulers simply do not have the time necessary to convert their latent strengths into actual strengths, outside of a few exceptions like the World Wars, which became *de facto* contests of attrition.

Thus, the first model of thus section, and third overall in the paper, includes the `CINC` score. In addition, I also make use of the data on alliances available in the Correlates of War to construct a variable `Alliance`, an integer variable that simply counts the number of secure alliances a state has that either existed prior to the war and persisted through it, or were formed during the war and persisted through it.[16] We might expect that states entering wars with strong alliance connections have secured themselves from attack from those states with which it is allied, and perhaps also gained access to extra-territorial resources (akin to the lend-lease arrangement that characterized American-British interactions from 1939-1941, for example). Although the `CINC` score may capture the averaged effect of short and long term material state potential, it lacks information on military modernity. To account for this, I also include `Quality`, or effectively, dollars per soldier.

I display the results from this estimation in Table 4a. The vast majority of the posterior density for `CINC` is larger than 0 (more that 95% of draws from the posterior after burn-in), indicating that being endowed with material capabilities, be they in the form of military expenditure or latent strength, reinforces winningness in war. The effect of `Alliance` and `Quality` both are ambiguous. This is easy to observe graphically; in Figure 3, I plot the posterior densities for Table 4. While the

[16] The data are available at http://www.correlatesofwar.org/COW2%20Data/Alliances/alliance.htm

Table 4a: Structured Estimates: Material Capabilities

Coefficient	Mean	$\widehat{R}$
`Constant`	-2.2300	1.000
	$[-3.200, -1.4269]$	
`CINC`	4.8519	1.001
	$[-0.1053, 9.5801]$	
`Alliance`	-0.0332	1.001
	$[-0.1955, 0.1273]$	
`Quality`	0.0059	1.001
	$[-0.0108, 0.0231]$	

Table 4a. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

mean of the posterior for `Alliance` is slightly below 0, and the mean for the posterior of `Quality` is slightly above 0, the simulated density straddles 0 nearly perfectly in both cases.

These preliminary results suggest two things. In the first place, the fact that `CINC` so obviously positively influences winningness in war suggests that the individual items are able, to some extent, to substitute for one another. That is, a state strong in latent categories but weak in primary military strength before the conflict breaks out may be able to bring those latent items to bear, and vice-versa.

In the second place, it suggests that after we account for coalition effects in the estimation procedure, as we do here to deal with dependence as I described above, including a variable capturing alliance effects does nothing. That is, allies not already a party to a war bring nothing for the table for their partners who are already involved. An educated guess would be that this might have to do with state perception of credibility; without vested interests in a costly conflict, i.e. that a state has been directly attacked, it or its alliance partners who are involved may have difficulty convincing enemies in war that it would intervene in the conflict if it is not ended favorably for the ally.

Finally, the ambiguous results of `Quality` are intriguing, in that they suggest that perhaps latent potential strength is more important than immediate military power on the outbreak of war. To see if this is in fact the case, I present in Table 4b the results from

Figure 3. Posterior Density of Model 3.

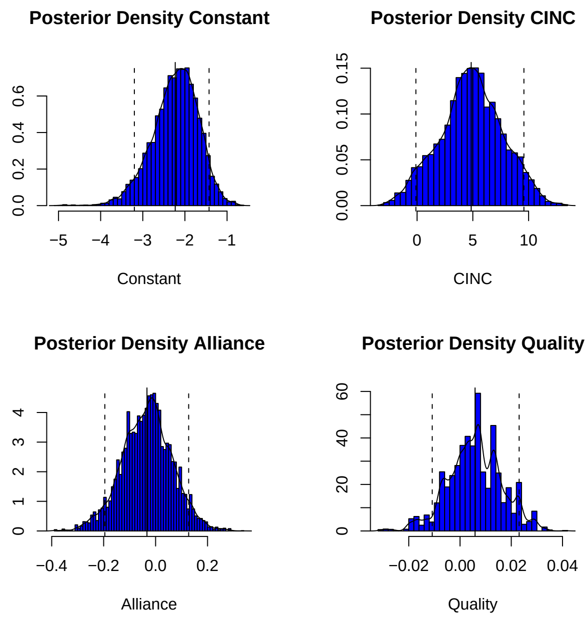


Figure 3. The posterior densities for the first chain. The solid vertical line indicates the posterior mean, while the dashed vertical lines indicate the 95% region of highest posterior density.

Table 4b: Structured Estimates: Individual Material Components

Coefficient	Mean	$\widehat{R}$
`Personnel`	0.04268 $[-0.3241, 0.4002]$	1.000
`Expend`	0.3783 $[-0.2136, 1.0090]$	1.000
`IRST`	2.4850 $[-2.0038, 6.7727]$	1.002
`Energy`	2.1918 $[-1.0741, 5.7404]$	1.002

Table 4b. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

separate estimations that replace `CINC` with the individual material components; if indeed latent material capability is more important than military strength on the outbreak of war, we would expect that the latent items, `IRST` and `Energy` trump the immediate items, `Expend` and `Personnel`. The table suggests that this is not so, a verdict that is unsurprising given that, as discussed above, most wars are short and rulers simply do not have enough time to translate material potential into a war machine.

What is somewhat surprising is that, not only do the latent items have ambiguous effects on winningness in war, but so too do the immediate military items. This suggests that a middle ground of sorts may be necessary; few conflicts are of the wrenching total war type that requires massive mobilization of societal resources, but most do require some commitment beyond the immediate force levels at hand. Thus, in Table 4c, I estimate the model using military personnel available at the *end* of a war. To the extent that this captures societal potential to mobilize additional soldiers and equipment, then it reflects the long-term capability of society. To the extent that it captures an initially well-equipped state that keeps its soldiers alive throughout the course of the conflict, it reflects immediate military capability.

The lesson of the table is that almost the entire posterior density is larger than 0 for both `Personnel` and `Expend`, suggesting that there is some sense in which a latent ability to mobilize soldiers contributes to winningness in war, keeping soldiers alive during the fighting contributes to winningness in war, or more likely, some combination thereof.

To recapitulate, the analysis of material capabilities I have presented here suggests that they have considerable ambiguity in their effect upon winningness in war. Having modeled coalitions explicitly, alliance ties outside the immediate conflict bring no advantage to the combatants. `Quality` does not systematically affect winningness in war, and while `CINC` does, none of the individual items which comprise it do.[17] More than 95% of posterior draws are larger than 0 for both `Personnel` and `Expend` when the end of war values appear in the estimation, suggesting that the long term ability of a state to raise or maintain soldiers and expenditure reinforces winningness in war to a greater degree than the immediate forces available upon the initial outbreak of war. The relatively weak effects, with

[17] Since the `CINC` variable is an arbitrary aggregation of the capabilities items, I also applied a dimensionality reduction scheme via principle components analysis. Examination of the eigenvalues suggested that two primary dimensions underlie the six capabilities items; running the analysis employing the rotated data derived from these first two eigenvectors did not appreciably add to the analysis, and has the drawback of making the results for difficult to interpret. Thus, I present the analysis for the "raw" data here.

Table 4c: Structured Estimates: Ending Military Capabilities

Coefficient	Mean ($\widehat{R}$)	Mean ($\widehat{R}$)
`Constant`	-2.2246 (1.000)	-2.2247 (1.000)
	[-3.1537, -1.4272]	[-3.1680, -1.4256]
`Personnel`	0.4314 (1.000)	
	[-0.0253, 0.9162]	
`Expend`		0.2729 (1.000)
		[-0.0237, 0.7738]
`Alliance`	-0.0203 (1.001)	-0.0198 (1.000)
	[-0.1798, 0.1500]	[-0.1861, 0.1462]
`Quality`	0.0039 (1.002)	0.0040 (1.002)
	[-0.0121, 0.0194]	[-0.0118, 0.0190]

Table 4c. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

the exception of `CINC`, of material capabilities on winningness in war suggest that they will not survive when considered in conjunction with the regime effects I examined in the first part of this section.

To test the robustness of the posterior distributions of the capabilities covariates, I re-estimate the model will controlling for the political variables I examined in the first part of this section. In Table 5a, I present a very simple model with `CINC` and `Polity` only. In Table 5b, I display the point estimates, including all the political variables previously analyzed as controls. The results are clear; the political variables retain their effects, while only military personnel at the end of the war has more than 95% of the posterior draws larger than 0.[18]

Finally, in Table 6 I interact `Polity` and the immediate capabilities variables; if scholars who argue that democracy reinforces winningness in war due to an improvement in performance of the soldiery, then we should expect that democratic states with extensive material capabilities ought to gain a boost in their winningness in war. The results of Table 6 yield a counter-intuitive finding, namely that democratic states with large armies are relatively less likely to win in war than those with smaller armies.[19] We might speculate that historically, states build large armies via conscription, and that in democracies, domestic opposition towards these extractive domestic policies may have undermined the war effort; American opposition to the Vietnam War is a prime example.

Table 5a: Structured Estimates: Individual Political Components

Coefficient	Mean	$\widehat{R}$
Constant	-2.2214	1.000
	[-3.2066, -1.4151]	
CINC	4.1331	1.000
	[-0.7104, 8.8965]	
Polity	0.07443	1.002
	[0.0226, 0.1303]	

Table 5a. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

A Ranking of States

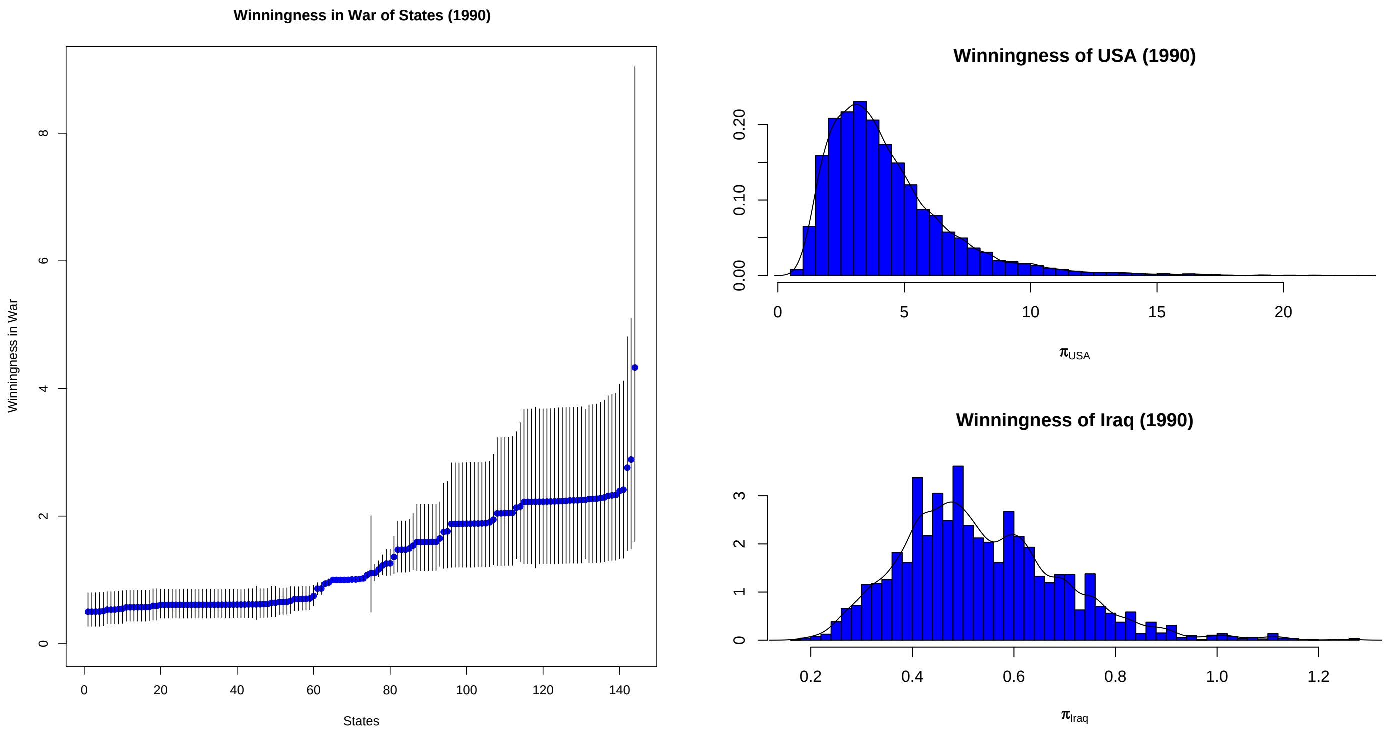
A great benefit of the coalitional Bradley-Terry model that I have presented and analyzed here is that the ability parameters, winningness in war, is transitive, and therefore may be used to establish a ranking of states from those with the greatest winningness to the least. Of course, any such ranking will be dependent upon the underlying model I use to generate the winningness ability parameters. I present a ranking based upon the simplest possible model that will still generate sufficient variation across states, that from Table 5a.

I plot the predicted winningness in war for each state in the international system for the year 1990 in Figure 4 on the left. The blue dots indicate the point estimates; the means of the posterior distribution, while the vertical bars indicate the empirical uncertainty around the point estimates generated by the simulation algorithm. Note that each vertical line indicates a posterior distribution with 95% of the mass between the upper and lower bounds given in the figure. The most powerful state in the world is unsurprisingly the United States and immediately following it are a host of western Eu-

[18] The Bayesian equivalent of a one-tailed test.

[19] I obtained ambiguous results interacting `Polity` with `Expend`, and so for the sake of brevity, I omit them.

Figure 4. A Ranking of Winningness in War.



ropean states. By these calculations, the weakest state is Saudi Arabia, led slightly by Qatar and Swaziland.

As a point of interest, I plot the distribution of American winningness in war and Iraqi winningness in war in 1990 on the right of Figure 4. The mean of American winningness in war is approximately $\exp\{\pi_{USA}(x_{USA})\} \approx 4.3285$, while the mean of the Iraqi winningness in war is $\exp\{\pi_{Iraq}(x_{Iraq})\} \approx 0.5352$. Given these estimates, the model suggests that the US would have prevailed over Iraq with probability 0.9600, with no coalition-building at all.

As I said, the ranking presented in Figure 4 is only as good as the model underlying it, and there are a few surprising features, for example, the Soviet Union ranks in the bottom half of all states in 1990, despite having just lost its superpower status. This indicates that further refinement of the underlying model would be welcome.

4 Conclusion

I have argued that we should conceptualize power in international relations in the style of Morgenthau and Dahl as a sort of bargaining power, subject to the outside option of going to war. To the extent that this is true, then measuring power reduces to measuring the ability of a state in war, its winningness. My analysis of the data suggests that winningness in war, and hence state power, depends to a great degree upon the underlying regime type and political life of a state. In addition, questions of selection effects notwithstanding, winningness in war seems to depend on material capabilities in a much more fragile and ambiguous way, and indeed, the effects of those capabilities on winningness very nearly disappear when we also control for political variables. To the extent that the procedure I have suggested here does indeed tap into state power, the implication is that scholars are incorrect to dismiss the relationship between power and outcomes by limiting their focus entirely to material capabilities.

The next steps in this project will attempt to deal with the fragile dependence of winningness upon traditional military considerations, in the first place by extending the analysis down to the battle level, where much finer grained data exists, and in the second place, by attempting to deal with potential selection effects.

Table 5b: Structured Estimates: Models 2 and 3.

	Model 1	
Coefficient	Mean	$\widehat{R}$
`Constant`	-2.0331 [-3.0103, -1.2192]	1.000
`Initiator`	0.722183 [0.1509, 1.3103]	1.000
`Polity*Initiator`	0.0159 [-0.0658, 0.0990]	1.001
`Polity*Target`	0.1593 [0.0726, 0.2482]	1.000
`CINC`	0.6792 [-4.9208, 6.3434]	1.000
`Alliance`	-0.06132 [-0.2646, 0.1402]	1.000
`Quality`	0.0120 [-0.0097, 0.0338]	1.000
`Personnel`	0.424261 [-0.0163, 1.0931]	1.003

Table 5b. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

Table 6: Structured Estimates

Coefficient	Mean	$\widehat{R}$
`Constant`	-2.0707 [-3.0442, -1.2637]	1.000
`Initiator`	0.8375 [0.3141, 1.3641]	1.000
`Polity*Initiator`	0.0521 [-0.0354 0.1388]	1.000
`Polity*Target`	0.1571 [0.0730, 0.2476]	1.000
`Polity*Personnel`	-0.4362 [-0.9945, 0.0107]	1.000

Table 6. Point estimates of parameter effect are given by the posterior mean. The interval below the point estimates is the empirical 95% region of highest posterior density.

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