Supplementary Files for "Peaceful Uncertainty: When Power Shocks Do Not Create Commitment Problems"

Derivations for Lemma 1

Before specifying the equilibrium parameters $\bar{p}$, $\underline{p}$ and x^*, we define the following terms:

- in any given period, since a settlement is reached when $\underline{p} \leq p_t \leq \bar{p}$ and war occurs otherwise in MPE, define $P = F(\bar{p}) - F(\underline{p})$ as the ex ante probability of peace at that period, before Nature makes that period's draw from $F(p)$.

- During bargaining at each period, $Q = \frac{c_A + c_B}{1 - \delta P}$ represents the expected present and future total surplus from avoiding war if a settlement is reached in equilibrium. Since war is costly, when peace prevails, $c_A + c_B$ is the surplus for that period, and the total expected surplus is equal to

$$\begin{aligned} Q &= c_A + c_B + \delta P(c_A + c_B + \delta P(c_A + c_B + \ldots \\ Q &= c_A + c_B + \delta P Q \\ Q &= \frac{c_A + c_B}{1 - \delta P}. \end{aligned}$$

- The total expected value of the game at the beginning of a given period can be defined similarly. If war occurs for sure in the model, the total value is $\frac{1 - c_A - c_B}{1 - \delta}$, which is the sum of two states' war continuation values. Incorporating the probability of peace and the surplus states receive from it, we get the total expected value of the game as $E(V) = \frac{1 - c_A - c_B}{1 - \delta} + Q$. Note that, if war is not possible in equilibrium, so that $P = 1$, $E(V) = \frac{1}{1 - \delta}$.

- Finally, due to the "take it or leave it" bargaining protocol, A makes the offers in each round, and A receives all the surplus from peace most of the time by making offers that make B indifferent between war and peace in equilibrium. The only exception is when the budget constraint binds, and A cannot force B to her war value as A cannot receive more than the most generous share from bargaining (x=1). Thus, there is a certain range of balance parameters $(p^*_A, \bar{p}]$ at which, B receives some or all of the surplus Q in equilibrium. At $\bar{p}$, A is indifferent between war and peace, thus, all of the surplus goes to B. p^*_A represents the highest value of the balance at which A receives all of the surplus from peaceful bargaining. Within this interval, B's share of the surplus gets larger as p_t gets closer to $\bar{p}$. Thus, in expectation, B receives the following amount of surplus from bargaining: $S_A = \int_{p_A^*}^{\bar{p}} \frac{p_t - p_A^*}{1-\delta} f(p_t) dp_t$.

We now characterize the endogenous parameters of the model. First, $\underline{p}$ that makes B indifferent between accepting the whole pie and going to war needs to satisfy the following equation:

$$1 + \delta(\frac{1 - p - c_B}{1 - \delta} + S_A) = \frac{1 - \underline{p} - c_B}{1 - \delta} \tag{1}$$

The right hand side (RHS) is what B receives if B attacks when the balance is $\underline{p}$ (when B is stronger than average based on *F(p)*). The left hand side (LHS) is the continuation value from accepting the most generous offer from A (x=0), and the expected payoff from the future. The expected future payoff has four components. First, future may entail a strong enough A that is willing to attack ($p_t > \bar{p}$); a strong enough B that attacks $p_t < \underline{p}$; peace prevails and A receives all the surplus from bargaining; and finally some of the surplus (S_A) goes to B through bargaining. In the first three scenarios, B receives its war payoff, and the fourth one adds S_A to B's payoff from its outside option of war.

Second, $\bar{p}$ represents the balance value that gives A an advantage over the long term average balance so that A is indifferent between keeping the whole pie to himself that period and attacking B. This indifference condition is represented by

$$1 + \delta(\frac{p - c_A}{1 - \delta} + (QP - S_A)) = \frac{\bar{p} - c_A}{1 - \delta} \tag{2}$$

As in the previous equation, the RHS is A's payoff from attacking B and ending the game when the balance favors A at $\bar{p}$. The LHS is A's payoff when A receives the whole issue at stake at period t (x=1), and expected payoff from future periods. As in the previous case, future could involve war initiated by either side, or peaceful bargaining. In all these scenarios, A at least receives his war payoff, which equals to $\frac{p - c_A}{1-\delta}$ in expectation. When peace prevails, A also enjoys all the surplus from peace (QP), except when the budget constraint binds and some of this surplus (S_A) goes to B.

To identify the range in which B receives some of the surplus, first observe that the two states' expected shares when peace prevails should sum up to the total value of the game, $E(V)$. Thus, when A receives all the surplus from bargaining at p_A^*, B's total share is her war payoff $\frac{1 - p_A^* - c_B}{1-\delta}$, while A receives $E(V) - \frac{1 - p_A^* - c_B}{1-\delta}$. The LHS is the same as in Equation 2, where A receives the largest feasible share from bargaining (x=1).

$$1 + \delta(\frac{p - c_A}{1 - \delta} + (QP - S_A)) = E(V) - \frac{1 - p_A^* - c_B}{1 - \delta} \tag{3}$$

Finally, the above equation can also be used to calculate the equilibrium offer x^* when peace prevails, i.e. when $\underline{p} \leq p_t \leq \bar{p}$. First, note that as long as it is feasible ($x \leq 1$), A prefers making the offer that leaves B indifferent between accepting and war. This offer solves the following equation:

$$1 - \bar{x} + \delta(\frac{1 - p - c_B}{1 - \delta} + S_A) = \frac{1 - p_t - c_B}{1 - \delta} \tag{4}$$

Equation 3 implies that $\bar{x} > 1$ when $p_t > p_A^*$. Thus, when $p_A^* \leq p_t \leq \bar{p}$, A offers $x = 1$ instead and leaves some of the surplus to B. Hence, the equilibrium offer is $x^* = \min\{1, \bar{x}\}$ when $\underline{p} \leq p_t \leq \bar{p}$.

The endogenous equilibrium parameters $\underline{p}$, $\bar{p}$, and x^* are simultaneously determined from the above non-linear system of equations. Since the non-linear system of equations in this lemma does not have a closed form solution, in our simulations we employ numerical optimization using the `BB` package in `R` to calculate the cutpoints for a given set of exogenous parameters.

Model Extension

The model in the manuscript has actors account for the present round's realization of the balance parameter in determining the cutpoints for attacking. How significant is it for the overall probability of peace that states take present realizations into account as opposed to only using past realizations? To see this, we compare states cutpoints when they only take into account past realizations versus both past and present. This comparison is presented in Figure A1. The green dashed lines are states' cutpoints ($\bar{p}^*$ for the top line and $\underline{p}^*$ for the bottom line representing A and B's cutpoints, respectively) when, at any given period t, states only use the past realizations from period 1 up to period t-1 to estimate the distribution. In contrast, the red solid lines are when at any given period t, states include period t's realization as well in their calculations for cutpoints (call them $\bar{p}^{**}$ and $\underline{p}^{**}$ for A and B, respectively) as in from Scenario 1 or 2 above. The resulting cutpoints are more extreme, and hence, peace becomes more likely. To see the intuition for why the second version is more peaceful, consider the case in which, at period t, the realized balance parameter exactly equals $\bar{p}^*$. This is the point when state A is indifferent between attacking and not attacking when only past realizations are taken into account, and assume, for the sake of the example, that state A attacks at this point when only past realizations are used to approximate the distribution. Now consider the second possibility, in which the present realization is also taken into account in calculations. This new extreme realization results in a revision of the estimated distribution. In particular, the mean of the estimated distribution increases, making the distribution, and hence the future outlook relatively more favorable to A compared to the past period's estimate. Thus, A no longer prefers attacking at $p = \bar{p}^*$, as it is no longer a fleeting advantage that creates a temporary window of opportunity and causes a commitment problem. Instead, A uses a more extreme cutpoint $\bar{p}^{**} > \bar{p}^*$ to attack B. Similar arguments establish that for B as well, more extreme realizations are needed to make attacking attractive in the second version that takes into account the present as well as the past realizations in approximating the distribution.

The manuscript focuses on the case where actors account for past *and* present realizations because (1) actors are likely to update expectations based on highly salient and readily available

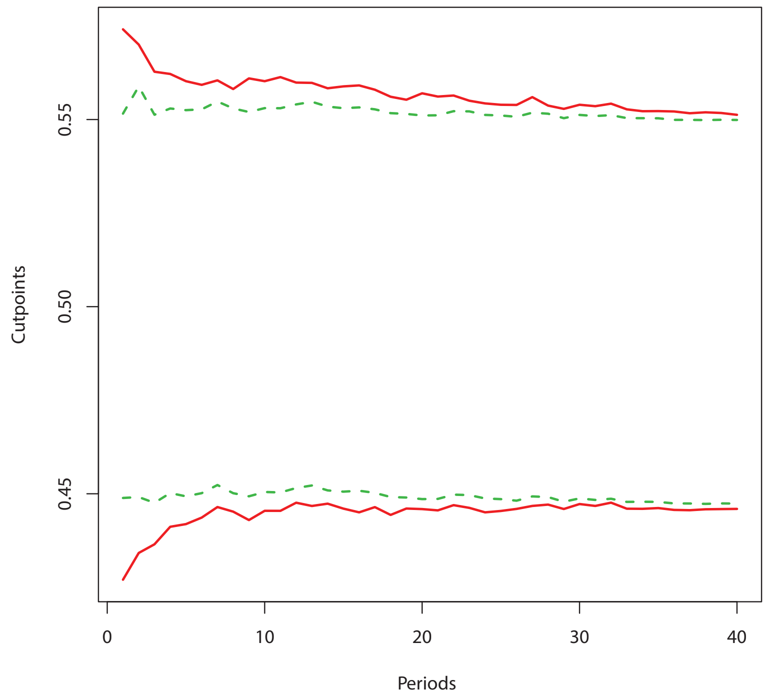

Figure A1: Cutpoints when estimates are based on past realizations only (dashed green) versus past and present (solid red)

information and (2) it is the substantively more interesting framework.

Robustness Tests for Quantitative Results

Table A1: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Rivalrous Directed Dyadis					
Outcome Variable					
War	0.01	0.1	0	1	9,321
Explanatory Variables					
Power Shock	0.17	0.38	0	1	9,321
Future Trend	0.01	0.10	-0.80	0.80	9,290
Controls Variables					
Relative Capabilities	0.50	0.24	0.007	0.993	9,321
Contiguity	0.776	0.417	0	1	9,321
Foreign Policy Similarity	0.82	0.19	-0.19	1	9,321
Peace Years	10.2	14.5	0	107	9,321
Politically Relevant Directed Dyads					
Outcome Variable					
War	0.001	0.04	0	1	142,400
Explanatory Variables					
Power Shock	0.15	0.35	0	1	142,400
Future Trend	0.004	0.05	-0.91	0.93	141,975
Controls Variables					
Joint Democracy	0.15	0.35	0	1	142,400
Relative Capabilities	0.48	0.42	0	1	142,400
Contiguity	0.23	0.42	0	1	142,400
Foreign Policy Similarity	0.73	0.21	-0.22	1	142,400
Peace Years	31.99	37.74	0	292	142,400

Table A2: Rivalrous Dyads: Rare Event Logistic Regression

	(1)	(2)	(3)	(4)	(5)
Power Shock	0.64***		0.54**	0.34	0.80***
	(0.23)		(0.25)	(0.59)	(0.24)
Small Positive Realization		0.47*			
		(0.26)			
Future Trend			-2.37*		
			(1.22)		
Power Shock*Trend			5.83***		
			(2.02)		
Annual Power Shift					-2.50**
					(1.13)
Relative Capabilities	-0.67	-0.99*	-0.62	0.45	-0.65
	(0.42)	(0.52)	(0.43)	(0.94)	(0.42)
Contiguity	-0.15	-0.14	-0.11	-0.71	-0.12
	(0.27)	(0.36)	(0.27)	(0.52)	(0.27)
Foreign Policy Similarity	-0.56	-0.47	-0.60	0.83	-0.56
	(0.51)	(0.70)	(0.51)	(1.32)	(0.51)
Peace Years	-0.33***	-0.28***	-0.34***	-0.12*	-0.33***
	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)
Constant	-2.96***	-3.09***	-2.99***	-4.24***	-3.04***
	(0.44)	(0.54)	(0.44)	(1.06)	(0.44)
N	9,766	8,053	9,735	2,380	9,766

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Firth logistic regression with directed rivalry dyad year as unit of analysis; standard errors clustered on the directed dyad. Models 1,3, and 5 include the full sample of observations. Model 2 drops observations with power shocks. Model 4 includes only those observations with *Future Trend* values in the most favorable quartile. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome.

Table A3: Rivalrous Dyads: Without Control Variables

	(1)	(2)	(3)	(4)	(5)
Power Shock	0.79***		0.61**	0.38	0.84***
	(0.26)		(0.30)	(0.63)	(0.25)
Small Positive Realization		0.26			
		(0.27)			
Future Trend			-1.02		
			(1.79)		
Power Shock*Trend			5.57**		
			(2.53)		
Annual Power Shift					-0.87
					(2.59)
Constant	-4.73***	-4.84***	-4.79***	-4.63***	-4.74***
	(0.14)	(0.18)	(0.15)	(0.26)	(0.14)
N	9,812	8,091	9,755	2,384	9,812

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis; standard errors clustered on the directed dyad. Models 1,3, and 5 include the full sample of observations. Model 2 drops observations with power shocks. Model 4 includes only those observations with *Future Trend* values in the most favorable quartile. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome.

Table A4: Rivalrous Dyads: Without Relative Capabilities as a Control Variable

	(1)	(2)	(3)	(4)	(5)
Power Shock	0.61**		0.53*	0.20	0.77***
	(0.27)		(0.29)	(0.62)	(0.26)
Small Positive Realization		0.41			
		(0.27)			
Future Trend			-2.30		
			(1.55)		
Power Shock*Trend			5.39**		
			(2.20)		
Annual Power Shift					-2.40*
					(1.31)
Contiguity	-0.15	-0.10	-0.12	-0.70	-0.13
	(0.29)	(0.44)	(0.30)	(0.65)	(0.30)
Foreign Policy Similarity	-0.49	-0.47	-0.54	1.20	-0.48
	(0.55)	(0.68)	(0.55)	(1.16)	(0.56)
Peace Years	-0.35***	-0.53***	-0.36***	-0.38	-0.35***
	(0.07)	(0.12)	(0.08)	(0.27)	(0.07)
Constant	-3.34***	-3.43***	-3.34***	-4.32***	-3.42***
	(0.45)	(0.53)	(0.45)	(0.75)	(0.46)
N	9321	7708	9290	2160	9321

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis; standard errors clustered on the directed dyad. Models 1,3, and 5 include the full sample of observations. Model 2 drops observations with power shocks. Model 4 includes only those observations with *Future Trend* values in the most favorable quartile. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome.

Table A5: Rivalrous Dyads: Interactive Effect Robustness

	(1)	(2)	(3)
Power Shock	0.21	0.44	0.74**
	(0.62)	(0.46)	(0.35)
Relative Capabilities	0.39	-0.74	-1.63**
	-1.17	-0.75	-0.7
Contiguity	-0.68	1.17*	-0.72**
	(0.63)	(0.64)	(0.31)
Foreign Policy Similarity	1.13	-0.83	-2.25***
	(1.10)	(0.71)	(0.81)
Peace Years	-0.38	-0.43***	-0.52***
	(0.26)	(0.14)	(0.13)
Constant	-4.47***	-4.00***	-0.39
	(0.92)	(0.75)	(0.78)
N	2,160	3,957	3,204
Pct. with Power Shock	9%	17%	23%

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis; standard errors clustered on the directed dyad. Full sample subset by future trend: Model 1 has the most favorable future trend (Future Trend < -0.02), Model 2 has neutral future trend, and Model 3 has most pessimistic future trend (Future Trend > 0.02). Power shock becomes increasingly associated with war as the trend becomes worse. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome.

Table A6: Rivalrous Dyads: Endogeneity Robustness

	Low Capabilities	Low Capabilities	Natural Disasters
Target Power Shock	0.45*	0.63***	0.61***
	(0.27)	(0.20)	(0.23)
Relative Capabilities	-0.86	0.50**	-1.15*
	(0.57)	(0.25)	(0.65)
Contiguity	-0.13	0.78***	-0.21
	(0.38)	(0.19)	(0.49)
Joint Democracy		-3.05***	
		(1.00)	
Foreign Policy Similarity	0.29	-0.71*	-0.21
	(0.72)	(0.37)	(0.79)
Peace Years	-0.37***	-0.12***	-0.58***
	(0.08)	(0.02)	(0.15)
Constant	-3.79***	-5.64***	-2.75***
	(0.62)	(0.37)	(0.61)
N	8501	122481	4012

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis (1 and 3) or politically relevant dyad year as unit of analysis (2); standard errors clustered on the directed dyad. Models remove endogenous arming from the shock indicator. In first two models, shocks indicate target state's capabilities were below expectations. Samples exclude observations where initiator capabilities exceeded expectations (endogenous arming cases). Third model codes shocks based on the number of fatalities in the target state from a natural disaster (measured in millions). We suggest caution in interpreting this result due to data quality issues. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models using only rivalrous dyads due to collinearity with the outcome.

Table A7: Pre-Nuclear Era

	(1)	(2)	(3)
Power Shock	0.82**	0.90***	0.34
	(0.32)	(0.33)	(0.64)
Future Trend		-4.06**	
		(1.74)	
Power Shock*Trend		4.45*	
		(2.57)	
Relative Capabilities	-0.61	-0.45	-0.20
	(0.60)	(0.63)	(1.22)
Contiguity	-0.08	-0.03	0.38
	(0.27)	(0.28)	(0.56)
Foreign Policy Similarity	-1.64***	-1.68***	-0.50
	(0.62)	(0.63)	(0.87)
Peace Years	-0.33***	-0.33***	-0.49*
	(0.08)	(0.08)	(0.29)
Constant	-2.04***	-2.20***	-3.02***
	(0.70)	(0.75)	(1.09)
N	5762	5734	1300

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis; standard errors clustered on the directed dyad. Specifications restricted to the pre-nuclear era. All results hold. Models 1 and 2 include the full sample of observations. Model 3 includes only those observations with *Future Trend* values in the most favorable quartile. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome.

Table A8: Rivalrous Dyads: 99% Confidence Interval Cutpoints

	(1)	(2)	(3)
Power Shock	0.76***	0.68**	0.35
	(0.29)	(0.30)	(0.63)
Future Trend		-1.96	
		(1.62)	
Power Shock*Trend		5.25**	
		(2.30)	
Relative Capabilities	-0.69	-0.64	0.39
	(0.48)	(0.49)	(1.18)
Contiguity	-0.11	-0.06	-0.66
	(0.30)	(0.31)	(0.64)
Foreign Policy Similarity	-0.51	-0.54	1.13
	(0.56)	(0.56)	(1.10)
Peace Years	-0.35***	-0.35***	-0.37
	(0.07)	(0.08)	(0.26)
Constant	-3.05***	-3.08***	-4.50***
	(0.52)	(0.52)	(0.92)
N	9321	9290	2160

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis; standard errors clustered on the directed dyad. Power shocks coded depending on whether realized dyadic balance follows outside the estimate 99% confidence interval cutpoints (as opposed to 95% bounds) All results hold. Models 1 and 2 include the full sample of observations. Model 3 includes only those observations with *Future Trend* values in the most favorable quartile. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome.

Table A9: Rivalrous Dyads: Wider Cutpoints

	(1)	(2)
Power Shock	0.94**	1.12***
	(0.37)	(0.43)
Future Trend		-0.79
		(1.8)
Power Shock*Trend		4.04
		(2.62)
Relative Capabilities	-0.44	-0.56
	(0.44)	(0.47)
Contiguity	-0.1	-0.11
	(0.28)	(0.3)
Foreign Policy Similarity	-0.5	-0.61
	(0.52)	(0.55)
Peace Years	-0.33***	-0.33***
	(0.07)	(0.07)
Constant	-3.01***	-2.95***
	(0.47)	(0.49)
N	9702	9429

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis; standard errors clustered on the directed dyad. Power shocks coded depending on whether realized dyadic balance falls outside of sufficiently wide cutpoints such that only 2% of observations are coded as shocks. Models 1 and 2 include the full sample of observations. We exclude results from a model subset to include only observations with *Future Trend* values in the most favorable quartile because shocks perfectly predict peace in these instances, consistent with the theoretical implications. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome.

Table A10: Rivalrous Dyads: Control for Country-Shock Proclivity

	(1)	(2)	(3)	(4)	(5)
Power Shock	0.55*		0.45	0.15	0.70**
	(0.29)		(0.31)	(0.63)	(0.28)
Small Positive Realization		0.47			
		(0.29)			
Future Trend			-2.12		
			(1.59)		
Power Shock*Trend			5.60**		
			(2.28)		
Annual Power Shift					-2.27*
					(1.35)
Relative Capabilities	-0.64	-1.03	-0.59	0.55	-0.62
	(0.49)	(0.64)	(0.50)	(1.24)	(0.50)
Contiguity	-0.03	0.01	0.00	-0.55	-0.01
	(0.33)	(0.48)	(0.34)	(0.68)	(0.33)
Foreign Policy Similarity	-0.57	-0.35	-0.62	1.16	-0.57
	(0.58)	(0.72)	(0.57)	(1.15)	(0.58)
Shock Rate	1.21	2.36**	1.33	2.86	1.11
	(1.09)	(1.10)	(1.07)	(2.19)	(1.11)
Peace Years	-0.34***	-0.52***	-0.35***	-0.36	-0.34***
	(0.08)	(0.12)	(0.08)	(0.26)	(0.08)
Constant	-3.30***	-3.62***	-3.34***	-5.28***	-3.35***
	(0.59)	(0.63)	(0.60)	(1.19)	(0.61)
N	9321	7708	9290	2160	9321

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis; standard errors clustered on the directed dyad. Models 1,3, and 5 include the full sample of observations. Model 2 drops observations with power shocks. Model 4 includes only those observations with *Future Trend* values in the most favorable quartile. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome. The fixed-effects predictive model used to generate the shock indicator does not allow the predictor coefficients to vary by state. This is problematic if predictors systematically underestimate some states' actual capabilities, artificially inducing "shocks." Shock Rate, a measure of the percentage of years in which the initiator's capabilities exceed the estimated bounds, controls for this possibility.

Table A11: Rivalrous Dyads: Cluster-Robust Standard Errors

	(1)	(2)
Power Shock	0.63**	0.54*
	(0.27)	(0.29)
Future Trend		-2.22
		(1.73)
Power Shock*Trend		5.44***
		(2.00)
Relative Capabilities	-0.67	-0.62
	(0.59)	(0.57)
Contiguity	-0.14	-0.10
	(0.10)	(0.10)
Foreign Policy Similarity	-0.53	-0.58
	(0.57)	(0.58)
Peace Years	-0.35***	-0.36***
	(0.06)	(0.06)
Constant	-3.00***	-3.02***
	(0.60)	(0.56)
N	9321	9290

$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p < 0.01$

Notes: Logistic regression with directed rivalry dyad year as unit of analysis; cluster-robust standard errors (Aronow, Samii, Assenova, 2015). Models 1 and 2 include the full sample of observations. Higher order terms for *Peace Years* are not shown. *Joint Democracy* drops out of the models due to collinearity with the outcome.

Benchmarking Estimates of Future Military Capabilities

The objective of the predictive model for future capabilities is to use publicly available data with broad spatial and temporal coverage to approximate the estimative approach leaders or intelligence agencies might use. The manuscript describes the validity of this approach based on prior scholarship (Fordham, 2011; Bell and Johnson, 2015) as well as National Intelligence Estimates from the US intelligence community. Ideally, we could benchmark our approach's predictions versus those from leaders or intelligence agencies. Unfortunately, this is challenging for numerous reasons. First, these estimates are not widely available in a systematic fashion. Second, the comparison is likely to be apples-to-oranges. Our model yields an aggregated capability prediction that includes military expenditures and personnel whereas other benchmarks includes one or the other. Third, existing predictions from, say, think tanks, do not necessarily represent leaders predictions. That is, the purported benchmark may not be a good benchmark.

Noting the impediments, we nonetheless attempt to benchmark projections versus 15 predictions from a RAND study that the Office of the Secretary of Defense funded.[1] Table 5 of that study estimates past and future military spending by country for the years 1950, 1960, 1970, 1980, 1990, 2000, and 2010. The countries in the study are US, USSR, Japan, China, West Germany, UK, France, India, South Korea, Taiwan, Brazil, Argentina, Turkey, Mexico, and Egypt. Because the report was produced in 1989 and our approach focuses on predictions for the next year, we focus the analysis on the 1990 predictions.

The benchmarking exercise includes the following steps.

1. Generate a scaling variable to place the RAND estimates and CINC measure of military spending on the same scale based on 1980 estimates (CINC military expenditures/RAND military expenditures).[2]
2. Multiply 1990 RAND spending estimate by the scaling factor. This provides a rough benchmark for our estimate of military expenditures in 1990.
3. Infer our model's estimate of military expenditures, as opposed to estimate of capabilities which is a function of expenditures and personnel (2*estimated 1990 capabilities – realized personnel).
4. Compare the 1990 scaled RAND estimate to the implied estimate from our model.

Figure A.2 shows the relationship between the two. A simple bivariate regression has an $R^2 = 0.84$. The large outlier in the figure is the Soviet Union where the RAND estimate is far higher

[1] See "Long-Term Economic and Military Trends, 1950-2010: A RAND Note," by Charles Wolf Jr., Gregory Hildebrandt, Michael Kennedy, Donald Putnam Henry, Katsuaki Terasawa, K.C. Yeh, Benjamin Zycher, Anil Bamezai, and Toshiya Hayashi. April 1989.

[2] This step facilitates making an apples-to-apples comparison. Otherwise, the CINC based measure captures state military spending as a percentage of global military spending while the RAND measure captures spending in billions of 1986 US dollars. That being said, a model making a non-scaled comparison of our raw projection to RAND's raw projection has an $R^2 = 0.88$.

than our projection (the latter of which was more accurate in hindsight).

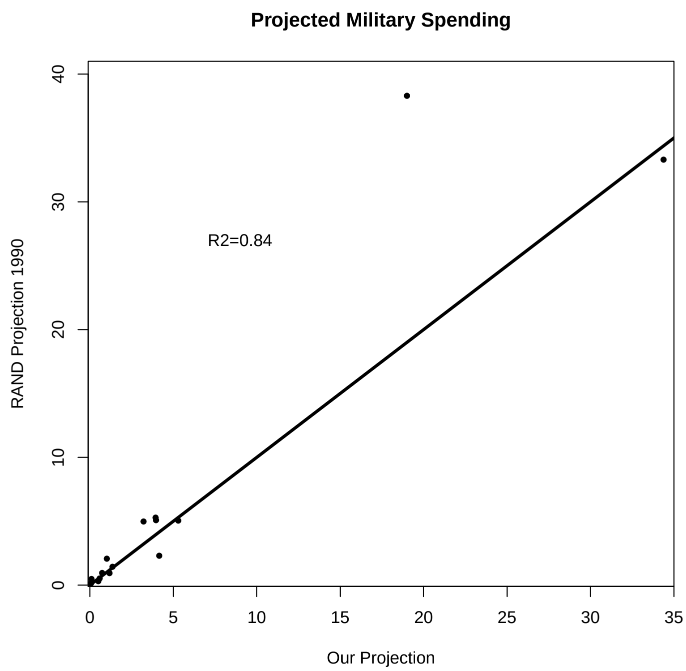

Figure A2: Comparison of implied military spending estimates from our approach versus one from RAND. Diagonal line represents a hypothetical perfect fit (1:1) between the two projections.