Energy resources and the risk of conflict in shared river basins

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Online Appendix

This appendix provides supplementary analyses described in the main text. The STATA replication dataset and do files include code for replicating these results.

I. Measuring river basin conflict and cooperation

To assess the robustness of our original analyses using militarized interstate disputes as the primary measure of conflict, we estimated models using four additional dependent variables to the baseline models originally reported in the paper (Table A6). The first is a measure of conflict events as coded by Kahlbenn and Bernauer (2012) in their dataset, International Water Conflict and Cooperation (IWCC); https://www.researchgate.net/profile/Thomas_Bernauer2/publication/256039984_International_Water_Cooperation_and_Conflict_A_New_Event_Dataset/links/5672793708aecc73dc0c633d.pdf. Events are coded on a conflict (to -6) and cooperation (to +6) scale for all river basin country pairs (dyads) for each year from 1997 to 2007. We created a dummy variable that equals one when a river dyad experiences one or more IWCC conflict events in a given year. The second measure is also an events database for water events from 1950-2008 as coded by International Water Events Database by Wolf and colleagues at Oregon State University (http://www.transboundarywaters.orst.edu/database/interwatereventdata.html). We take the water event intensity scale (BAR) which ranges from -7 to +7 and code a dummy variable that equals 1 when a river dyad experiences one or more BAR conflict events (-7 to -1) in a given year. Because we have good temporal coverage for this events data, we also create a measure for cooperation coded 1 when a river dyad experiences one of more BAR cooperative events (1-7) and 0 otherwise. Our fourth measure is designed to capture river-based cooperation in a riparian dyad using data on the onset of river treaty commitments. We use a version of the TFDD river treaty data compiled by Zawahri and Mitchell (2011) that equals one in a riparian dyad year if one or more new river treaties were signed that year and 0 otherwise. Bivariate cross-tabulations show the relationship between upstream/downstream configuration and MID onset (Table A1), IWCC conflict onset (Table A2), TFDD river treaty onset (Table A3), TFDD conflict event onset (Table A4), and TFDD cooperation event onset (Table A5).

By adding these additional dependent variable measures, we present stronger evidence in favor of our theoretical argument. Our key hypothesis is that militarized conflicts are less likely and cooperation more likely over shared basins under the *Downstream Energy* scenario than in the other scenarios (*Joint Energy, Upstream Energy, No Energy).* Here we highlight some of the main findings (Table A6 without controls; Table A7 with controls) using a baseline model with 3 control variables (lowest democracy score, major power dummy, logged capability ratio).

- First, we find that *Joint Energy* dyads are significantly more likely to experience MIDs and TFDD conflict events and significantly less likely to sign river treaties or have cooperative events over their rivers than *Downstream Energy* dyads.

- Second, *Upstream Energy* dyads are more likely to experience MIDs and TFDD conflict events than *Downstream Energy* dyads, but do not vary in terms of cooperative behavior.
- Third, while there are few differences between *Downstream Energy* and *No Energy* dyads in the multivariate models, we observe more distinctions in the bivariate cross-tabulations (Tables A1-A5). *Downstream Energy* dyads have a higher % of river treaties than *No Energy* dyads (2.38% vs. 1.36%), a lower rate of IWCC conflict events (4.18% vs. 8.8%), and a smaller number of MIDs (6.18% vs. 7.59%).
- Taken together, these results provide a more complete picture and stronger support for our hypothesis that cooperation is easier to achieve in situations where downstream states have energy resources that can be potentially traded to upstream states who control water supplies.

We also include two models in the Appendix that use fatal MIDs as an alternative dependent variable (Table A8). We find that *Upstream Energy and No Energy* dyads have a higher risk for fatal MIDs than *Downstream Energy* dyads, while there is no difference in fatal conflict risks with *Joint Energy* dyads.

II. Including Alternative Measures for Energy/Economic Dependence

Table A9 shows analyses of our baseline MID model adding Primary Energy Consumption (PEC) from the Correlates of War's national capability data to control more directly for states' energy consumption levels. Our key results are robust to inclusion of this variable. The analyses presented in Table A10 show that the inclusion of dyadic trade does not alter our primary results. *Downstream Energy* dyads are less like to engage in MIDs compared to *Joint Energy* and *Upstream Energy* dyads when including measures for PEC and dyadic trade.

III. Including Additional Water Scarcity & Dam Measures

To ensure that our results are robust to states' overall water scarcity levels in shared river basins, we include variables of water dependence and average precipitation from Zawahri and Mitchell (2011). Our results are robust with water scarcity measures included: *Joint Energy* and *Upstream Energy* dyads have higher risks of MIDs than *Downstream Energy* dyads (Table A9).

In the article, we control for the number of dams and hydropower dams that upstream and downstream states possess. This information was coded directly by the authors using the ICOLD World Register of Dams dataset. As seen in Table A9, the results for our baseline MID model are robust when we include a count measure for upstream/downstream dams or hydropower dams. Our theory works best for dyads where the upstream state has the ability to control water flow. We estimated a logit MID model conditional on whether the upstream state has one (or more) hydroelectric dams (81.5% of our dyads). As expected, the MID results are the same for this constrained set of dyads as we originally report. The results are insignificant for *Joint Energy* and *Upstream Energy* variables in the set of dyads that do not have hydroelectric dams in the upstream state, but the *No Energy* dyads have a higher risk for MIDs than the omitted *Downstream Energy* dyads. Given that our sample is dominated by situations where upstream

states have some ability to control water flow, we use the larger dataset but control for dams in some of the reported models in the paper.

IV. Controlling for Landlocked States

Our results are robust with a land-locked variable (Table A9), which we include to capture the fact that such states may be more dependent on rivers for navigation.

V. Controlling for Institutional Riparian Cooperation and Shared IGOs

In Table A11, we add four institutional measures to our baseline MID model capturing the presence of one or more TFDD treaties (in general), treaties with provisions for water quality, treaties with provisions for navigational issues, and a general shared IGO membership count from the Correlates of War IGO dataset. The TFDD variables do not reduce MID onset; shared IGOs reduce the chances for militarized conflict, similar to some studies in the democratic peace literature. Our primary results are robust to the inclusion of these controls; militarized conflicts are less likely in *Downstream Energy* dyads than *Joint Energy* and *Upstream Energy* dyads.

Table A1. MID Onset, Energy Resources, and Upstream/Downstream Relationships

Scenario	No MID Onset	MID Onset	Total
Downstream Energy	2,917 (93.82%)	192 (6.18%)	3,109 (19.71%)
	Pearson Chi2(1) = 23.6931 Pr= 0.000		
Joint Energy	1,629 (84.45%)	300 (15.55%)	1,929 (12.23%)
	Pearson Chi2(1) = 149.0548 Pr= 0.000		
Upstream Energy	1,861 (91.99%)	162 (8.01%)	2,023 (12.83%)
	Pearson Chi2(1) = 0.3310 Pr= 0.565		
No Energy	8,049 (92.41%)	661 (7.59%)	8,710 (55.23%)
	Pearson Chi2(1) = 14.2839 Pr= 0.000		
Total	14,456 (91.66%)	1,315 (8.34%)	15,771 (100%)
Pearson Chi2(3) = 157.0563 Pr= 0.000			

Note: % in No MID Onset and MID Onset are row percentages. % in Total is column percentages.

Table A2. IWCC Conflict Events, Energy Resources, and Upstream/Downstream Relationships

Scenario	No Conflict Event Onset	Conflict Event Onset	Total
Downstream Energy	504 (95.82%)	22 (4.18%)	526 (23.88%)
	Pearson Chi2(1) = 7.0890 Pr= 0.008		
Joint Energy	481 (94.50)	28 (5.50%)	509 (23.10%)
	Pearson Chi2(1) = 1.5648 Pr= 0.211		
Upstream Energy	376 (92.38%)	31 (7.62%)	407 (18.47%)
	Pearson Chi2(1) = 0.6433 Pr= 0.423		
No Energy	694 (91.20%)	67 (8.80%)	761 (34.54%)
	Pearson Chi2(1) = 8.0734 Pr= 0.004		
Total	2,055 (93.28%)	148 (6.72%)	2,203 (100%)
Pearson Chi2(3) = 12.4086 Pr= 0.006			

Note: % in No Conflict Event Onset and Conflict Event Onset are row percentages. % in Total is column percentages.

Table A3. River Treaty Onset, Energy Resources, and Upstream/Downstream Relationships

Scenario	No River Treaty Onset	River Treaty Onset	Total
Downstream Energy	3,116 (97.62%)	76 (2.38%)	3,192 (13.96%)
	Pearson Chi2(1) = 16.2151 Pr= 0.000		
Joint Energy	1,993 (98.57%)	29 (1.43%)	2,022 (8.84%)
	Pearson Chi2(1) = 0.2332 Pr= 0.629		

Upstream Energy	2,054 (98.09%)	40 (1.91%)	2,094 (9.16%)
	Pearson Chi2(1) = 1.8255 Pr= 0.177		
No Energy	15,345 (98.64%)	212 (1.36%)	15,557 (68.04%)
	Pearson Chi2(1) = 12.4919 Pr= 0.000		
Total	22,508 (98.44%)	357 (1.56%)	22,865 (100%)
Pearson Chi2(3) = 19.8149 Pr= 0.000			

Note: % in No River Treaty Onset and River Treaty Onset are row percentages. % in Total is column percentages.

Table A4. TFDD Conflict, Energy Resources, and Upstream/Downstream Relationships

Scenario	No TFDD Conflict	TFDD Conflict	Total
Downstream Energy	444 (84.09%)	84 (15.91%)	528 (25.61%)
	Pearson Chi2(1) = 10.7018 Pr= 0.001		
Joint Energy	392 (78.09%)	110 (21.91%)	502 (24.35%)
	Pearson Chi2(1) = 0.4097 Pr= 0.522		
Upstream Energy	258 (76.33%)	80 (23.67%)	338 (16.39%)
	Pearson Chi2(1) = 1.8716 Pr= 0.171		
No Energy	537 (77.38%)	157 (22.62%)	694 (33.66%)
	Pearson Chi2(1) = 1.8728 Pr= 0.171		
Total	1,631 (79.10%)	431 (20.90%)	2,062 (100%)
Pearson Chi2(3) = 11.0787 Pr= 0.011			

Note: % in No TFDD Conflict and TFDD Conflict are row percentages. % in Total is column percentages.

Table A5. TFDD Cooperation, Energy Resources, and Upstream/Downstream Relationships

Scenario	No TFDD Cooperation	TFDD Cooperation	Total
Downstream Energy	149 (28.22%)	379 (71.78%)	528 (25.61%)
	Pearson Chi2(1) = 3.4856 Pr= 0.062		
Joint Energy	178 (35.46%)	324 (64.54%)	502 (24.35%)
	Pearson Chi2(1) = 4.8828 Pr= 0.027		
Upstream Energy	118 (34.91%)	220 (65.09%)	338 (16.39%)
	Pearson Chi2(1) = 2.2141 Pr= 0.137		
No Energy	204 (29.39%)	490 (70.61%)	694 (33.66%)
	Pearson Chi2(1) = 2.0973 Pr= 0.148		
Total	649 (31.47%)	1,413 (68.53%)	2,062 (100%)
Pearson Chi2(3) = 9.5298 Pr= 0.023			

Note: % in No TFDD Cooperation and TFDD Cooperation are row percentages. % in Total is column percentages.

Table A6. Models using Different Dependent Variables

	MIDs	IWCC	River Treaty	TFDD Conflict	TFDD Cooperation
Joint Energy	1.058***	0.267	-0.545**	0.416**	-0.228
	(0.099)	(0.293)	(0.222)	(0.164)	(0.142)
Upstream Energy	0.291***	0.628**	-0.235	0.511***	-0.186
	(0.111)	(0.288)	(0.198)	(0.176)	(0.155)
No Energy	0.198**	0.806***	-0.266*	0.444***	0.028
	(0.086)	(0.254)	(0.144)	(0.150)	(0.131)
Year	1.542***	0.237***	0.775***	0.770	9.628***
	(0.511)	(0.052)	(0.281)	(1.179)	(1.053)
Year squared	-0.000***	0.000	-0.000***	-0.000	-0.002***
	(0.000)	(.)	(0.000)	(0.000)	(0.000)
Constant	-1521.773***	-476.413***	-773.764***	-760.736	-9503.588***
	(504.872)	(104.610)	(275.382)	(1166.800)	(1042.015)
Number of observations	15771	2203	22865	2062	2062
AIC	8915.659	1060.890	3634.298	2113.585	2446.027
BIC	8961.654	1089.378	3682.523	2147.374	2479.816

Note: Standard errors in parentheses. *p<0.10, **p<0.05, ***p<0.01.

Table A7. Baseline Models with Different Dependent Variables, Adding Control Variables

	MIDs	IWCC	River Treaty	TFDD Conflict	TFDD Cooperation
Joint Energy	0.883***	-0.039	-0.450**	0.535***	-0.313*
	(0.102)	(0.358)	(0.228)	(0.185)	(0.169)
Upstream Energy	0.277**	0.272	-0.193	0.566***	-0.105
	(0.112)	(0.328)	(0.200)	(0.181)	(0.161)
No Energy	-0.019	0.024	-0.134	0.114	0.337**
	(0.089)	(0.301)	(0.149)	(0.167)	(0.149)
Low Democracy	-0.038***	-0.104***	0.038***	0.022***	0.014*
	(0.005)	(0.017)	(0.007)	(0.008)	(0.007)
Major Power	0.529***	0.632*	-0.250	-0.492***	0.473***
	(0.093)	(0.355)	(0.162)	(0.175)	(0.157)
Ln Capability Ratio	-0.334***	-0.451***	0.148***	-0.270***	0.148**
	(0.033)	(0.124)	(0.046)	(0.069)	(0.059)
Year	0.415	0.243***	0.907***	-1.343	8.705***
	(0.523)	(0.074)	(0.299)	(1.277)	(1.164)
Year squared	-0.000	0.000	-0.000***	0.000	-0.002***
	(0.000)	(.)	(0.000)	(0.000)	(0.000)
Constant	-410.604	-488.429***	-903.809***	1333.950	-8600.188***
	(516.396)	(148.348)	(292.590)	(1263.082)	(1151.602)
Number of observations	15771	1836	22455	1995	1995
ROC	0.6423	0.7349	0.6406	0.6114	0.6285
ROC vs. Baseline (χ^2)	34.24	0.64	0.08	4.39	1.72
AIC	8743.050	755.451	3574.927	2045.793	2335.193
BIC	8812.044	799.574	3647.100	2096.179	2385.579

Note: Standard errors in parentheses. *p<0.10, **p<0.05, ***p<0.01. Baseline model is a model excluding energy/geography scenario variables.

Table A8. Models with Fatal MIDs as a Dependent Variable

	FMID 1	FMID 2
Joint Energy	0.213	0.092
	(0.224)	(0.228)
Upstream Energy	0.680***	0.659***
	(0.199)	(0.201)
No Energy	0.974***	0.640***
	(0.161)	(0.165)
Low Democracy		-0.038***
		(0.008)
Major Power		0.117
		(0.191)
Ln Capability Ratio		-0.412***
		(0.061)
Year	-0.861	-2.112**
	(0.809)	(0.825)
Year squared	0.000	0.001**
	(0.000)	(0.000)
Constant	838.175	2074.837**
	(799.320)	(814.810)
Number of observations	15495	15495
ROC		0.6553
ROC vs. Baseline (χ^2)		10.88
AIC	4035.313	3946.155
BIC	4081.203	4014.990

Note: Standard errors in parentheses. *p<0.10, **p<0.05, ***p<0.01. Baseline model is a model excluding energy/geography scenario variables.

Table A9. MIDs Models, Adding Additional Control Variables (PEC. Dams. Water Scarcity. Land-locked)

	Baseline	PEC	All Dam	HydroDam1	HydroDam2	Water	Land-locked
Joint Energy	0.883***	0.887***	0.778***	0.870***	0.865***	0.849***	0.790***
	(0.102)	(0.104)	(0.105)	(0.106)	(0.102)	(0.102)	(0.102)
Upstream Energy	0.277**	0.279**	0.218*	0.307**	0.253**	0.253**	0.249**
	(0.112)	(0.112)	(0.124)	(0.126)	(0.114)	(0.113)	(0.113)
No Energy	-0.019	-0.032	-0.042	-0.005	-0.011	-0.036	0.074
	(0.089)	(0.089)	(0.097)	(0.098)	(0.090)	(0.090)	(0.090)
Low Democracy	-0.038***	-0.038***	-0.047***	-0.047***	-0.040***	-0.040***	-0.041***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
Major Power	0.529***	0.495***	0.760***	0.994***	0.501***	0.518***	0.449***
	(0.093)	(0.127)	(0.131)	(0.125)	(0.093)	(0.092)	(0.093)
Ln Capability Ratio	-0.334***	-0.342***	-0.433***	-0.452***	-0.325***	-0.353***	-0.302***
	(0.033)	(0.034)	(0.043)	(0.042)	(0.034)	(0.034)	(0.034)
State A PEC		0.000					
		(0.000)					
State B PEC		-0.000***					
		(0.000)					
Upstream State's Number of Dam			-0.000				
			(0.000)				
Downstream State's Number of			0.000**				
Dam			(0.000)				
Upstream State's Number of				-0.001***			
Hydroelectric Dam				(0.000)			
Downstream State's Number of				0.000***			
Hydroelectric Dam				(0.000)			
Upstream State's Hydroelectric					0.230***		
Dam (Dummy)					(0.089)		
Downstream State's Hydroelectric					0.003		
Dam (Dummy)					(0.083)		
Water Dependence (low)						23.663***	
						(8.164)	
Average Precipitation (low)						-0.688***	
						(0.143)	
Land-locked							-0.408***
							(0.065)

Year		0.356	0.324	0.399	0.268	0.473	0.397
		(0.524)	(0.606)	(0.612)	(0.525)	(0.525)	(0.524)
Year squared		-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant		-352.261	-324.376	-399.623	-264.667	-466.684	-395.604
		(517.088)	(598.814)	(604.970)	(518.726)	(518.340)	(517.398)
Number of observations	15771	15771	12085	12085	15771	15735	15771
ROC	0.6423	0.6446	0.6652	0.6669	0.6449	0.6563	0.6538
ROC vs. Baseline (χ^2)	34.24	29.67	31.68	31.58	26.31	23.12	17.08
AIC	8743.050	8738.430	6913.239	6888.510	8739.780	8695.138	8702.292
BIC	8812.044	8822.755	6994.636	6969.907	8824.105	8779.438	8778.952

Note: Standard errors in parentheses. *p<0.10, **p<0.05, ***p<0.01.

Table A10. MID Models, Adding Dyadic Trade Variables

	KSG Import	KSG Export	COW Import	COW Trade
Joint Energy	0.830***	0.824***	0.862***	0.858***
	(0.105)	(0.105)	(0.104)	(0.104)
Upstream Energy	0.266**	0.266**	0.275**	0.275**
	(0.113)	(0.113)	(0.112)	(0.112)
No Energy	-0.108	-0.111	-0.026	-0.027
	(0.090)	(0.090)	(0.089)	(0.089)
Low Democracy	-0.038***	-0.039***	-0.040***	-0.040***
	(0.005)	(0.005)	(0.005)	(0.005)
Major Power	0.489***	0.478***	0.503***	0.497***
	(0.099)	(0.099)	(0.096)	(0.097)
Ln Capability Ratio	-0.345***	-0.344***	-0.332***	-0.332***
	(0.034)	(0.034)	(0.034)	(0.034)
Imports State A from B (Gleditsch)	0.000			
	(0.000)			
Exports State A to B (Gleditsch)		0.000**		
		(0.000)		
Imports State A from B (COW)			0.000	
			(0.000)	
Total Trade (COW)				0.000
				(0.000)
Year	-0.938	-0.925	0.441	0.444
	(0.593)	(0.594)	(0.524)	(0.524)
Year squared	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	929.879	917.108	-435.591	-438.159
	(586.059)	(586.390)	(517.238)	(517.210)
Number of observations	14868	14868	15771	15771
ROC	0.6428	0.6429	0.6429	0.6429
ROC vs. Baseline (χ^2)	28.84	27.30	29.08	28.27
AIC	8429.000	8427.796	8743.853	8743.422
BIC	8505.069	8503.866	8820.512	8820.081

Standard errors in parentheses. *p<0.10, **p<0.05, ***p<0.01.

Table A11. MID Models, Adding TFDD Treaty and IGOs Variables

	Any Treaty	Nav.Treaty	Qual.Treaty	IGOs
Joint Energy	0.881***	0.879***	0.901***	0.861***
	(0.101)	(0.102)	(0.103)	(0.104)
Upstream Energy	0.271**	0.284**	0.280**	0.279**
	(0.112)	(0.112)	(0.112)	(0.112)
No Energy	-0.021	-0.019	-0.007	-0.015
	(0.089)	(0.089)	(0.090)	(0.089)
Low Democracy	-0.034***	-0.041***	-0.036***	-0.042***
	(0.005)	(0.005)	(0.005)	(0.006)
Major Power	0.569***	0.504***	0.555***	0.537***
	(0.095)	(0.094)	(0.096)	(0.093)
Ln Capability Ratio	-0.334***	-0.334***	-0.334***	-0.332***
	(0.033)	(0.034)	(0.033)	(0.033)
Any Treaty (TFDD)	-0.174*			
	(0.104)			
Navigation Treaty (TFDD)		0.203		
		(0.125)		
Quality Treaty (TFDD)			-0.150	
			(0.143)	
IGOs				0.002
				(0.002)
Year	0.517	0.328	0.497	0.286
	(0.527)	(0.525)	(0.529)	(0.535)
Year squared	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-510.142	-324.670	-490.820	-283.083
	(520.749)	(518.256)	(522.635)	(528.437)
Number of observations	15771	15771	15771	15771
ROC	0.6397	0.6429	0.6406	0.6425
ROC vs. Baseline (χ^2)	32.87	33.43	29.82	24.72
AIC	8742.185	8742.490	8743.933	8743.862
BIC	8818.845	8819.150	8820.592	8820.522

Standard errors in parentheses. *p<0.10, **p<0.05, ***p<0.01.