Relative Water Scarcity and International Behavior:
Evidence from Post-Soviet Central Asia

Appendix

Coding procedures for interactions data

General notes

The majority of the data come from an extensive search of the EastView Database. I searched for permutations of the words 'water', 'hydro,' 'electric', 'gas', and 'oil' in combination with at least one of the five post-Sovet Central Asian countries. I flagged pertinent articles, then compiled these chronologically into events. Full text of the pertinent articles and a full listing of the chronological events, with citations, are available on request. I then cut down the chronological events to those that involved one of the pertinent dyads (the full database includes events involving single countries and additional dyads) and that met the coding criteria below.

Cooperative interactions

An cooperative is coded to have occurred in a given month if the event lays out clear expectations for and/or clearly impacts at least one of the following:

1. Price or terms of payment for energy products (including hydroelectricity)
2. Quantity of energy products to be delivered
3. Price or terms of payment for water
4. Quantity of water to be delivered

NOTE: a resumption of an old agreement (or return to original levels of delivery) IS coded as an agreement. For example, if gas delivery is suspended in January and delivery is resumed in Febru-

ary, then February is coded to have an agreement event.

Conflictual interactions

A conflictual interaction is coded to have occurred in a given month if the following conditions are met:

1. The event involves EITHER the use of violent force with objective of forceably changing the distribution of water and/or energy,
2. OR the event involves a unilateral, negative, and substantial change to at least one of the following:
   (a) Quantity of energy products to be delivered
   (b) Quantity of water to be delivered
3. OR the event is the 'failure' or 'collapse' of negotiations concerning an agreement (as defined above) necessary to govern resource management in the near future

NOTE: while I believe it is appropriate to consider failed negotiations as breaks in cooperation, I test each of the models using an alternative coding that does not include failed negotiations.

Robustness checks

Using pre-2000 monthly averages

In these models, the scarcity variable is constructed as follows: First, monthly averages are obtained using the 1992-1999 data on inflows to the upstream reservoirs. Second, for each month from January 2000- December 2010, the appropriate monthly average is subtracted from the observed inflow. Finally, the result is converted to standard deviations. This procedure mirrors the one used for the main water scarcity measure; the only difference is that the out-of-sample data are used to construct the monthly averages.

Table 1 and Table 2 use the full sample to determine the effect of scarcity on cooperative and conflictual interactions, respectively. For each dependent variable, Models 1 and 2 are logit models with robust standard errors, and Models 3 and 4 are conditional logit models (dyad fixed effects). The results are similar to those in the main analysis, although they are somewhat more consistent for cooperative interactions than conflictual ones.

Table 1: Occurrence of different kinds of interaction, pre-2000 scarcity

	Cooperative interactions			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.213^{**}	0.270^{***}	0.257^{***}	0.268^{***}
	(0.097)	(0.084)	(0.069)	(0.072)
History of coop.		2.186^{***}		0.310
		(0.635)		(0.708)
Growing season		-0.130		-0.131
		(0.188)		(0.176)
Second half		0.107		0.194
		(0.107)		(0.192)
Energy Difference		-0.003^{***}		-0.0003
		(0.001)		(0.003)
Exchange		1.210^{***}		
		(0.355)		
Syr Darya		0.132		
		(0.259)		
Constant	-1.881^{***}	-2.492^{***}		
	(0.330)	(0.405)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Table 2:

	Conflictual interactions, pre-2000 scarcity			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.148^{*}	0.127^{*}	0.210^{***}	0.113
	(0.090)	(0.067)	(0.073)	(0.076)
History of conflict.		2.533^{***}		1.858^{***}
		(0.751)		(0.640)
Growing season		-0.439^{*}		-0.444^{**}
		(0.237)		(0.205)
Second half		0.808^{**}		0.869^{***}
		(0.338)		(0.268)
Energy Difference		-0.004^{***}		-0.00001
		(0.001)		(0.005)
Exchange		1.718^{***}		
		(0.463)		
Syr Darya		0.250		
		(0.276)		
Constant	-2.128^{***}	-3.441^{***}		
	(0.374)	(0.381)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Using an indicator variable for extreme scarcity

In these models, the scarcity variable captures only more extreme levels of relative scarcity. It is an indicator variable that takes a value of one if water is at least one standard deviation more scarce than the (1992-2010) monthly average and zero otherwise. As above Table 3 and Table 4 use the full sample to determine the effect of scarcity on cooperative and conflictual interactions, respectively. For each dependent variable, Models 1 and 2 are logit models with robust standard errors, and Models 3 and 4 are conditional logit models (dyad fixed effects). Again, the results are similar to those in the main analysis, with scarcity having a positive and statistically significant effect on all three interactions.

Table 3: Occurrence of cooperative interactions, extreme scarcity

	Model 1	**Model 2**	**Model 3**	**Model 4**
Extreme water scarcity	0.765***	0.850***	0.717***	0.828***
	(0.211)	(0.176)	(0.173)	(0.188)
History of coop.		1.992***		0.169
		(0.567)		(0.713)
Growing season		−0.076		−0.077
		(0.189)		(0.176)
Second half		0.037		0.123
		(0.110)		(0.196)
Energy Difference		−0.003***		−0.0003
		(0.001)		(0.003)
Exchange		1.188***		
		(0.333)		
Syr Darya		−0.004		
		(0.247)		
Constant	−2.293***	−2.767***		
	(0.352)	(0.348)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

***p < .01; **p < .05; *p < .1
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Table 4: Occurrence of conflictual interactions, extreme scarcity

	Model 1	**Model 2**	**Model 3**	**Model 4**
Extreme water scarcity	0.847^{***}	0.645^{***}	0.826^{***}	0.567^{***}
	(0.249)	(0.198)	(0.191)	(0.213)
History of conflict		2.438^{***}		1.788^{***}
		(0.714)		(0.642)
Growing season		-0.416^{*}		-0.419^{**}
		(0.241)		(0.205)
Second half		0.714^{*}		0.792^{***}
		(0.365)		(0.271)
Energy Difference		-0.005^{***}		-0.0005
		(0.001)		(0.005)
Exchange		1.705^{***}		
		(0.438)		
Syr Darya		0.175		
		(0.255)		
Constant	-2.587^{***}	-3.644^{***}		
	(0.456)	(0.343)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Inclusion of lagged scarcity

In these models a lagged scarcity term is included. Although I believe the current month scarcity levels to be the appropriate ones, it is possible that there are lingering effects of past scarcity. Following the same pattern as above Table 5, and Table 6 use the full sample to determine the effect of scarcity on cooperative and conflictual interactions, respectively. For each dependent variable, Models 1 and 2 are logit models with robust standard errors, and Models 3 and 4 are conditional logit models (dyad fixed effects). The current month scarcity variable follows the same pattern as in the main analysis: a positive and statistically significant effect on any interactions and on all interactions. However, in this case, current month water scarcity does not have a statistically significant effect in Model 4 of Table 6. On the other hand, the lagged scarcity variable does have an affect on conflictual interactions in Models 1-3 of Table 6, suggesting there may be a lingering effect of scarcity on the propensity of countries to engage in conflictual actions.

Table 5: Occurrence of cooperative interactions, includes lagged scarcity

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.314^{***}	0.348^{***}	0.332^{***}	0.345^{***}
	(0.101)	(0.105)	(0.103)	(0.105)
Water Scarcity Lagged	0.040	0.039	0.053	0.062
	(0.049)	(0.050)	(0.100)	(0.102)
History of coop.		2.132^{***}		0.198
		(0.639)		(0.713)
Growing season		-0.088		-0.090
		(0.190)		(0.176)
Second half		0.094		0.181
		(0.111)		(0.194)
Energy Difference		-0.003^{***}		-0.001
		(0.001)		(0.003)
Exchange		1.219^{***}		
		(0.366)		
Syr Darya		0.052		
		(0.270)		
Constant	-1.930^{***}	-2.484^{***}		
	(0.329)	(0.416)		
Fixed effects?	N	N	Y	Y
N	1441	1320	1441	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Models 1 and 2 are logits with dyad-clustered robust standard errors.

Models 3 and 4 are conditional logits with fixed effects.

Table 6: Occurrence of conflictual interactions, includes lagged scarcity

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.222^{**}	0.193^{**}	0.241^{**}	0.181
	(0.109)	(0.078)	(0.109)	(0.113)
Water Scarcity Lagged	0.242^{**}	0.139^{**}	0.260^{**}	0.137
	(0.111)	(0.063)	(0.111)	(0.114)
History of conflict		2.436^{***}		1.724^{***}
		(0.731)		(0.642)
Growing season		-0.414^{*}		-0.421^{**}
		(0.237)		(0.205)
Second half		0.754^{**}		0.838^{***}
		(0.354)		(0.269)
Energy Difference		-0.005^{***}		-0.001
		(0.001)		(0.005)
Exchange		1.767^{***}		
		(0.468)		
Syr Darya		0.198		
		(0.271)		
Constant	-2.169^{***}	-3.405^{***}		
	(0.088)	(0.374)		
Fixed effects?	N	N	Y	Y
N	1441	1320	1441	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Models 1 and 2 are logits with dyad-clustered robust standard errors.

Models 3 and 4 are conditional logits with fixed effects.

Three-month scarcity

Another possibility is that water scarcity has a cumulative effect. To address this possibility, I create a three-month average scarcity variable, following the same procedure as the other relative scarcity variables. Following the same pattern as above, **??**, and **??** use the full sample to determine the effect of scarcity on both cooperative and conflictual interactions, respectively. For each dependent variable, Models 1 and 2 are logit models with robust standard errors, and Models 3 and 4 are conditional logit models (dyad fixed effects). This scarcity variable is also significantly and positively correlated with the occurrence of all three types of interaction.

Table 7: Occurrence of cooperative interactions, 3-month scarcity

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.335^{**}	0.350^{**}	0.368^{***}	0.380^{***}
	(0.150)	(0.138)	(0.112)	(0.119)
History of coop.		2.067^{***}		0.120
		(0.652)		(0.713)
Growing season		-0.077		-0.078
		(0.188)		(0.175)
Second half		0.110		0.193
		(0.102)		(0.194)
Energy Difference		-0.003^{***}		-0.0004
		(0.001)		(0.003)
Exchange		1.226^{***}		
		(0.371)		
Syr Darya		0.049		
		(0.273)		
Constant	-1.912^{***}	-2.482^{***}		
	(0.326)	(0.426)		
Fixed effects?	N	N	Y	Y
N	1430	1320	1430	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Table 8: Occurrence of conflictual interactions, 3-month scarcity

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.483^{***}	0.338^{***}	0.521^{***}	0.323^{**}
	(0.131)	(0.098)	(0.122)	(0.129)
History of conflict		2.411^{***}		1.696^{***}
		(0.722)		(0.643)
Growing season		-0.406^{*}		-0.413^{**}
		(0.239)		(0.205)
Second half		0.750^{**}		0.836^{***}
		(0.359)		(0.269)
Energy Difference		-0.005^{***}		-0.001
		(0.001)		(0.005)
Exchange		1.772^{***}		
		(0.466)		
Syr Darya		0.199		
		(0.272)		
Constant	-2.158^{***}	-3.402^{***}		
	(0.388)	(0.373)		
Fixed effects?	N	N	Y	Y
N	1430	1320	1430	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Models 1 and 2 are logits with dyad-clustered robust standard errors.

Models 3 and 4 are conditional logits with fixed effects.

Contiguity

These models include a contiguity indicator variable instead of the exchange one. The contiguous dyads are: Kazakh-Kyrgyz, Kazakh-Uzbek, Kyrgyz-Uzbek, Kyrgyz-Tajik, Tajik-Uzbek (Syr), Tajik-Uzbek (Amu), and Turkmen-Uzbek.

Table 9: Occurrence of different interactions, including contiguity control

	coop		**non**	
	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.332***	0.321***	0.330***	0.189***
	(0.107)	(0.101)	(0.085)	(0.060)
Contiguous	1.862***	1.139**	2.140***	1.273*
	(0.431)	(0.449)	(0.775)	(0.688)
History of coop.		3.568***		
		(0.638)		
History of conflict				4.385***
				(0.734)
Growing season		−0.086		−0.390*
		(0.186)		(0.228)
Second half		0.061		0.504***
		(0.080)		(0.171)
Syr Darya		0.135		0.279
		(0.415)		(0.519)
Constant	−3.361***	−3.455***	−3.867***	−4.255***
	(0.296)	(0.294)	(0.689)	(0.477)
Fixed effects?	N	N	N	N
N	1452	1320	1452	1320

***p < .01; **p < .05; *p < .1
All models are logits with dyad-clustered robust standard errors.

Include energy difference

These models include an additional control variable for the difference in per capita energy production across countries to capture the reliance of one dyad on the other. This measure includes the production of coal, natural gas, and crude oil. To make them comparable, I convert these production levels to British Thermal Units (BTU) using the conversion rates suggested but the United States Energy Information Administration (www.eia.gov). Population data are obtained from the World Development Indicators (http://data.worldbank.org/data-catalog/world-development-indicators). I then calculate the difference between the maximum and minimum producer. Although these data are only available at the yearly level, they do exhibit some variation over time.

Table 10: Occurrence of cooperative interactions, include energy difference

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.328***	0.365***	0.354***	0.372***
	(0.112)	(0.113)	(0.091)	(0.095)
History of coop.		2.152***		0.243
		(0.646)		(0.709)
Growing season		−0.088		−0.090
		(0.190)		(0.176)
Second half		0.101		0.191
		(0.107)		(0.193)
Energy Difference		−0.003***		−0.001
		(0.001)		(0.003)
Exchange		1.214***		
		(0.368)		
Syr Darya		0.052		
		(0.270)		
Constant	−1.920***	−2.493***		
	(0.331)	(0.413)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

***p < .01; **p < .05; *p < .1
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Table 11: Occurrence of noncooperative interactions, include energy difference

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.330^{***}	0.257^{***}	0.361^{***}	0.242^{**}
	(0.091)	(0.070)	(0.098)	(0.102)
History of conflict		2.491^{***}		1.796^{***}
		(0.735)		(0.640)
Growing season		-0.423^{*}		-0.429^{**}
		(0.241)		(0.205)
Second half		0.781^{**}		0.854^{***}
		(0.348)		(0.268)
Energy Difference		-0.004^{***}		-0.001
		(0.001)		(0.005)
Exchange		1.742^{***}		
		(0.464)		
Syr Darya		0.205		
		(0.275)		
Constant	-2.164^{***}	-3.427^{***}		
	(0.382)	(0.377)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Models 1 and 2 are logits with dyad-clustered robust standard errors.

Models 3 and 4 are conditional logits with fixed effects.

Exclusion of "failed negotiations" from conflictual interactions

These models exclude failed negotiations from the definition of conflictual interactions, as described in the coding procedures above. Following the same pattern as above, Table 12 use the full sample to determine the effect of scarcity onconflictual interactions (cooperative interactions have not changed). For each dependent variable, Models 1 and 2 are logit models with robust standard errors, and Models 3 and 4 are conditional logit models (dyad fixed effects). This scarcity variable is also significantly and positively correlated with the occurrence of all three types of interaction.

Table 12: Occurrence of conflictual interactions, no failed negotiations

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.216**	0.168**	0.235**	0.144
	(0.109)	(0.085)	(0.111)	(0.116)
History of conflict		2.790***		2.057**
		(0.838)		(0.854)
Growing season		−0.405*		−0.412*
		(0.222)		(0.234)
Second half		0.575**		0.599**
		(0.274)		(0.280)
Energy Difference		−0.005***		0.001
		(0.001)		(0.006)
Exchange		1.845***		
		(0.450)		
Syr Darya		0.018		
		(0.205)		
Constant	−2.532***	−3.539***		
	(0.387)	(0.359)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

***p < .01; **p < .05; *p < .1
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Only water-related events

The dependent variable for these models includes only events directly related to the quantity of water or to the price or quantity of hydroelectricity. I strongly believe that energy events should be included as well, since any agreement concerning energy necessarily affects the way water is managed. However, Table 13 and Table 14 show that the major findings are robust to their exclusion. For each dependent variable, Models 1 and 2 are logit models with robust standard errors, and Models 3 and 4 are conditional logit models (dyad fixed effects). Water scarcity is positively associated with both cooperative and conflictual interactions in all models, although the results are not statistically significant in the non-fixed effects models for cooperative interactions. The fact that the results are larger and more robust for conflictual interactions than cooperative ones may suggest that scarcity inclines countries to take direct conflictual activities, but more indirect cooperative ones (i.e. through the issue of energy).

Table 13: Occurrence of cooperative interactions

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.215	0.259	0.240*	0.263*
	(0.249)	(0.232)	(0.129)	(0.135)
History of coop.		−0.490		−2.270
		(1.696)		(1.837)
Growing season		0.214		0.218
		(0.200)		(0.256)
Second half		−0.072		−0.075
		(0.196)		(0.268)
Exchange		0.584*		
		(0.311)		
Syr Darya		1.406***		
		(0.533)		
Constant	−2.984***	−4.243***		
	(0.243)	(0.507)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

***p < .01; **p < .05; *p < .1
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Table 14: Occurrence of conflictual interactions

	Model 1	**Model 2**	**Model 3**	**Model 4**
Water scarcity	0.582***	0.369**	0.566***	0.391**
	(0.205)	(0.172)	(0.143)	(0.159)
History of conflict		1.892***		1.128
		(0.620)		(1.289)
Growing season		−0.346		−0.346
		(0.223)		(0.291)
Second half		0.496*		0.509
		(0.276)		(0.335)
Exchange		0.232		
		(0.228)		
Syr Darya		2.947***		
		(0.875)		
Constant	−3.223***	−5.987***		
	(0.322)	(0.762)		
Fixed effects?	N	N	Y	Y
N	1452	1320	1452	1320

***p < .01; **p < .05; *p < .1
Models 1 and 2 are logits with dyad-clustered robust standard errors.
Models 3 and 4 are conditional logits with fixed effects.

Multinomial logit models, with controls

These models are the same as Table 4 in the main article, but with the addition of history controls. History variables for both cooperation and conflict are included. The results are similar, although cooperative interactions barely miss conventional levels of statistical significance in the 3-category version.

Table 15: Occurrence of interactions, multinomial logit models with history variables

		Model 1	**Model 2**
water scarcity	*cooperative*	0.166	0.194*
		(0.103)	(0.106)
	conflictual	0.092	0.099
		(0.120)	(0.124)
	both		0.526***
			(0.164)
history of coop.	*cooperative*	1.214	1.609*
		(0.854)	(0.901)
	conflictual	1.005	1.426
		(0.975)	(1.048)
	both		5.850***
			(1.184)
history of confl.	*cooperative*	2.457***	3.157***
		(0.766)	(0.778)
	conflictual	4.346***	5.058***
		(0.861)	(0.883)
	both	4.346***	2.915***
		(0.861)	(1.056)
constant	*cooperative*	−2.675***	−2.780***
		(0.137)	(0.145)
	conflictual	−3.442***	−3.571***
		(0.181)	(0.193)
	both		−4.729***
		(0.181)	(0.280)
	N	1320	1320

***p < .01; **p < .05; *p < .1

Survival analysis results

This section contains the numerical results of the survival analysis that was presented graphically in the main paper. I coded the relationships between the countries over time (rather than the occurrence of an interaction). In this coding, a cooperative period ends with the unilateral breaking of an agreement. A conflictual period ends with the signing of a new agreement. I then used a Cox proportional hazard model to examine the probability of transitioning between periods, as shown in Table 16. The effect of water scarcity on the end of a conflictual period (i.e. signing an agreement) and on the end of a cooperative period (i.e. breaking an agreement) is negative and statistically significant, suggesting that scarcity makes the end of the existing kind of relations (be the cooperative or conflictual) more likely.

Table 16: Survival analyses

	conflictual period	**cooperative period**
Water scarcity	-0.147^{**}	-0.183^{**}
	(0.073)	(0.071)
N	537	1239

Both models are Cox proportional hazard models. $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$