Supplemental Appendix For

The need for willingness and opportunity: Analyzing where and when environmental variability influences conflict in the Sahel

Contents

This appendix first reports summary statistics for all variables used in our analyses in Table A1. We then proceed to report several robustness models used to test the sensitivity of our results. In Table A2, we begin by omitting all variables and fixed effects from our models to illustrate that the results are not driven by the inclusion of the former, which could induce inferential biases due to autocorrelation.[1]

Next, in Table A3, we remove the interaction term from our main models to illustrate that the effects of neither *Sahara transition zone*$_{it}$ nor *NDVI (mean)*$_{it-1}$ is robust in terms of sign and significance unless one accounts for their conditional relationship using an interactive term. Table A4 then reports our main models with and without the interaction using the 'lfe' package in R, which provides a more robust assessment of fixed effects models with clustering.[2]

Next, in Table A5, we conduct two additional tests to explore a potential causal impact. We begin by re-estimating our main models, adding an interaction between country and year fixed effects to account for all country-specific features that vary over time (e.g., democratization, GDP, population), and which might confound the results. In the last four columns in Table A5, we add to our main models interactions of country fixed effects with the time

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[1]Schrodt, Philip A. "Seven deadly sins of contemporary quantitative political analysis." Journal of peace research 51, no. 2 (2014): 287-300.

[2]Simen Gaure. "Package 'lfe'." (2011). `ftp://ctan.uib.no/pub/cran/web/packages/lfe/lfe.pdf`.

trend, which is akin to a synthetic control approach.[3]

Finally, Table A6 re-analyzes the same specifications from Table 1 from the main article, using a count model instead of OLS. Indeed, while OLS is now widely considered the standard for linear analysis, count models are specifically designed to handle count data, where the dependent variable is an integer, is bound from zero below, and unbounded above. Considering our reliance on a two-way fixed effects approach, we rely on Allison and Waterman[4] and deploy a Poisson model with fixed effects by country and month, considering that negative binomial models are not 'true' fixed effects model according to this setting. Our results generally hold in this specification, with two exceptions: (i) the interaction term just falls short of significance for *Rebel (ACLED)*$_{it}$ ($p = 0.109$), and (ii) the relationship between our interaction and nonstate conflict is now negative and statistically significant. Crucially, our results regarding the conditional relationship between a higher-than-average willingness to engage in violence in harsh-climate locations and the opportunity to initiate attacks during times of greater abundance within these regions hold across Tables A2-A6.

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[3]Carey, John M., and Yusaku Horiuchi. "Compulsory voting and income inequality: evidence for Lijphart's proposition from Venezuela." Latin American Politics and Society 59, no. 2 (2017): 122-144.

[4]Allison, Paul D., and Richard P. Waterman. "Fixed–effects negative binomial regression models." Sociological methodology 32, no. 1 (2002): 247-265.

Summary Statistics

Table A1: Summary Statistics for Dependent and Independent Variables

	Min	Median	Mean	Max	Std. Dev.
State (ACLED)$_{it}$	0	0	0.009	75	0.265
Rebel (ACLED)$_{it}$	0	0	0.003	37	0.118
State (GED)$_{it}$	0	0	0.004	32	0.138
Nonstate (GED)$_{it}$	0	0	0.001	30	0.066
Sahara transition zone$_{it}$	0	0	0.065	1	0.247
NDVI (mean)$_{it-1}$	-0.140	0.275	0.353	0.894	0.251
Log NT (sum)$_{it}$	0	0	1.495	5.344	1.707
Log population$_{it}$	0	4.226	3.924	7.259	1.293

Sensitivity Analyses

Table A2: Regression Estimates of Conflict Determinants – Baseline Specifications

	State (ACLED)	Rebel (ACLED)	State (GED)	Nonstate (GED)
	(5)	(6)	(7)	(8)
Sahara transition zone$_{it}$	−0.002	0.001	0.0002	0.0005
	(0.002)	(0.001)	(0.001)	(0.0004)
NDVI (mean)$_{it-1}$	0.014***	0.004***	0.006***	0.003***
	(0.001)	(0.0004)	(0.0005)	(0.0002)
Sahara transition zone$_{it}$ × NDVI (mean)$_{it-1}$	0.014*	0.013***	0.013***	−0.003*
	(0.007)	(0.003)	(0.004)	(0.002)
Constant	−0.012***	−0.003***	−0.005***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.0003)
Observations		1,953,816		
R^2	0.0002	0.0001	0.0001	0.0001
Adjusted R^2	0.0002	0.0001	0.0001	0.0001

Standard errors clustered by grid cell in parentheses; logging was done in base 10.

*** p<0.01, ** p<0.05, * p<0.1

DV stands for 'dependent variable.'

Table A3: Regression Estimates of Conflict Determinants – No Interaction

	State (ACLED)	Rebel (ACLED)	State (GED)	Nonstate (GED)
	(9)	(10)	(11)	(12)
Sahara transition zone$_{it}$	-0.002^{***}	0.001^{*}	-0.0003	-0.001^{***}
	(0.001)	(0.0003)	(0.0003)	(0.0002)
NDVI (mean)$_{it-1}$	-0.002^{*}	0.0003	0.0001	-0.001^{***}
	(0.001)	(0.001)	(0.001)	(0.0003)
DV_{it-1}	0.725^{***}	0.611^{***}	0.685^{***}	0.389^{***}
	(0.0005)	(0.001)	(0.001)	(0.001)
Log NT (sum)$_{it}$	0.001^{***}	0.0005^{***}	0.001^{***}	0.0003^{***}
	(0.0001)	(0.0001)	(0.0001)	(0.00004)
Log population$_{it}$	0.002^{***}	0.001^{***}	0.001^{***}	0.001^{***}
	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Log τ_t	0.002^{***}	0.001	0.0005	0.001^{***}
	(0.001)	(0.0003)	(0.0004)	(0.0002)
Constant	-0.014^{*}	0.001	-0.003	-0.005^{*}
	(0.007)	(0.004)	(0.004)	(0.002)
Observations		1,947,324		
R^2	0.528	0.369	0.470	0.152
Adjusted R^2	0.528	0.369	0.470	0.152

Standard errors clustered by grid cell in parentheses; logging was done in base 10; fixed effects by month and country where included in each model, although none is reported here.

*** p<0.01, ** p<0.05, * p<0.1

DV stands for 'dependent variable.'

Table A4: Regression Estimates of Conflict Determinants – FELM

	Non-Interaction				Interaction			
	SA	RA	SG	NSG	SA	RA	SG	NSG
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
$Sahara\ transition\ zone_{it}$	-0.002^{***}	0.001	-0.0002	-0.001^{***}	-0.004^{***}	-0.001^{*}	-0.002^{**}	-0.001^{**}
	(0.001)	(0.001)	(0.001)	(0.0003)	(0.001)	(0.001)	(0.001)	(0.0003)
$NDVI\ (mean)_{it-1}$	-0.001	0.001	0.0003	-0.001^{*}	-0.002	0.0003	0.0001	-0.001^{*}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$Sahara\ transition\ zone_{it} \times NDVI\ (mean)_{it-1}$					0.008^{**}	0.009^{**}	0.006^{*}	-0.002^{**}
					(0.003)	(0.004)	(0.003)	(0.001)
DV_{it-1}	0.725^{***}	0.611^{***}	0.685^{***}	0.389^{***}	0.725^{***}	0.611^{***}	0.685^{***}	0.389^{***}
	(0.114)	(0.143)	(0.125)	(0.062)	(0.114)	(0.143)	(0.125)	(0.062)
$Log\ NT\ (sum)_{it}$	0.001^{***}	0.0004^{***}	0.001^{***}	0.0003^{***}	0.001^{***}	0.0004^{***}	0.001^{***}	0.0003^{***}
	(0.0001)	(0.0001)	(0.0001)	(0.00005)	(0.0001)	(0.0001)	(0.0001)	(0.00005)
$Log\ population_{it}$	0.002^{***}	0.001^{***}	0.001^{***}	0.001^{***}	0.002^{***}	0.001^{***}	0.001^{***}	0.001^{***}
	(0.0005)	(0.0001)	(0.0002)	(0.0001)	(0.0005)	(0.0001)	(0.0002)	(0.0001)
$Log\ \tau_t$	0.002^{***}	0.001	0.001	0.001^{***}	0.002^{***}	0.001	0.001	0.001^{***}
	(0.001)	(0.001)	(0.001)	(0.0003)	(0.001)	(0.001)	(0.001)	(0.0003)
Observations	1,947,324				1,947,324			
R²	0.528	0.369	0.470	0.152	0.528	0.369	0.470	0.152
Adjusted R²	0.528	0.369	0.470	0.152	0.528	0.369	0.470	0.152

Standard errors clustered by grid cell in parentheses; logging was done in base 10; fixed effects by month and country where included in each model,
although none is reported here.
*** p<0.01, ** p<0.05, * p<0.1
DV stands for 'dependent variable.'

Table A5: Regression Estimates of Conflict Determinants – Temporal Confounders

	Country × Year FEs				Country FEs × τ			
	SA	RA	SG	NSG	SA	RA	SG	NSG
	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
Sahara transition zone$_{it}$	−0.004***	−0.001**	−0.002**	−0.001**	−0.004***	−0.002**	−0.002**	−0.001**
	(0.001)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.001)	(0.001)	(0.0004)
NDVI (mean)$_{it-1}$	−0.002*	0.0001	−0.00002	−0.001***	−0.002*	−0.00003	−0.00003	−0.001***
	(0.001)	(0.001)	(0.001)	(0.0003)	(0.001)	(0.001)	(0.001)	(0.0003)
Sahara transition zone$_{it}$ × *NDVI (mean)*$_{it-1}$	0.008	0.009***	0.006**	−0.002	0.008	0.010***	0.006**	−0.002
	(0.005)	(0.003)	(0.003)	(0.002)	(0.005)	(0.003)	(0.003)	(0.002)
DV$_{it-1}$	0.723***	0.610***	0.684***	0.388***	0.723***	0.611***	0.684***	0.389***
	(0.0005)	(0.001)	(0.001)	(0.001)	(0.0005)	(0.001)	(0.001)	(0.001)
Log NT (sum)$_{it}$	0.001***	0.001***	0.001***	0.0002***	0.001***	0.001***	0.001***	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(4.18E-05)	(0.0001)	(0.0001)	(0.0001)	(0.00004)
Log population$_{it}$	0.002***	0.001***	0.001***	0.0007***	0.002***	0.001***	0.001***	0.001***
	(0.0002)	(0.0001)	(0.0001)	(6.10E-05)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Log τ$_t$	0.077*	−0.018	0.016	0.013	−0.010	−0.003	−0.004	−0.002
	(0.045)	(0.023)	(0.025)	(0.015)	(0.021)	(0.010)	(0.011)	(0.007)
Constant	−0.388*	0.098	−0.080	−0.069	0.054	0.020	0.023	0.009
	(0.233)	(0.118)	(0.128)	(0.076)	(0.115)	(0.058)	(0.063)	(0.038)
Observations	1,947,324				1,947,324			
R²	0.529	0.370	0.471		0.529	0.369	0.470	0.152
Adjusted R²	0.529	0.370	0.470		0.529	0.369	0.470	0.152

Standard errors clustered by grid cell in parentheses; logging was done in base 10; fixed effects by month, year, country, and country × year where included in model 21-24, although none is reported here; fixed effects by month and country in addition to interaction between country fixed effects and τ were included in models 24-28, although none is reported.

*** p<0.01, ** p<0.05, * p<0.1
DV stands for 'dependent variable.'

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Table A6: Regression Estimates of Conflict Determinants – Count FE

	State (ACLED) (29)	Rebel (ACLED) (30)	State (GED) (31)	Nonstate (GED) (32)
Sahara transition zone$_{it}$	−0.345*** (0.081)	0.303*** (0.101)	0.074 (0.095)	−0.015 (0.289)
NDVI (mean)$_{it-1}$	−0.089 (0.063)	0.582*** (0.115)	0.004 (0.090)	−0.307* (0.159)
Sahara transition zone$_{it}$ × *NDVI (mean)*$_{it-1}$	1.476*** (0.271)	0.543 (0.339)	1.143*** (0.321)	−4.053*** (1.241)
DV$_{it-1}$	0.072*** (0.001)	0.158*** (0.002)	0.178*** (0.002)	0.284*** (0.005)
Log NT (sum)$_{it}$	0.141*** (0.008)	0.188*** (0.014)	0.154*** (0.012)	0.171*** (0.020)
Log population$_{it}$	1.895*** (0.018)	1.569*** (0.032)	1.637*** (0.026)	1.633*** (0.041)
Log τ_t	1.332*** (0.049)	0.838*** (0.082)	1.145*** (0.066)	1.325*** (0.119)
Constant	−28.210*** (0.828)	−38.942 (990.200)	−40.152 (990.183)	−40.371 (1,627.059)
Observations	1,947,324	1,947,324	1,947,324	1,947,324
Log Likelihood	−65,234.400	−26,840.690	−36,203.290	−14,407.470
Akaike Inf. Crit.	130,604.800	53,817.380	72,542.590	28,950.930

Standard errors clustered by grid cell in parentheses; logging was done in base 10; fixed effects by month and country where included in each model, although none is reported here.

*** p<0.01, ** p<0.05, * p<0.1

DV stands for 'dependent variable.'