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Economic Shocks and Civil Conflict: A Comment†

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Edward Miguel, Shanker Satyanath, and Ernest Sergenti (2004), henceforth MSS, argue that lower rainfall levels and negative rainfall shocks increase conflict risk in sub-Saharan Africa. This conclusion rests on their finding of a negative correlation between conflict in t and rainfall growth between t − 1 and t − 2. I show that this finding is driven by a (counterintuitive) positive correlation between conflict in t and rainfall levels in t − 2. If lower rainfall levels or negative rainfall shocks increased conflict, MSS's finding should have been due to a negative correlation between conflict in t and rainfall levels in t − 1. In the latest data, conflict is unrelated to rainfall. (*JEL* D74, E32, O11, O17, O47)

Does poor economic performance cause violent civil conflict? Paul Collier and Anke Hoeffler's (1998, 2004) and James D. Fearon and David D. Laitin's (2003) empirical work suggests this is the case. Their findings are not based on exogenous changes in the economic environment, however, and could reflect feedback from conflict to economic performance or omitted social and political factors. To address these concerns, MSS (2004) examine the link between (exogenous) rainfall and civil conflict in sub-Saharan Africa for the period 1979–1999. Their empirics lead them to the conclusion that *higher levels of rainfall are associated with significantly less conflict* (e.g., MSS 2004, 737). Or, equivalently, lower rainfall levels are associated with significantly more conflict. MSS (2004) explain this association by negative rainfall shocks reducing incomes and thereby increasing conflict risk. Their focus on exogenous rainfall shocks is an important step forward. MSS's (2004) study has advanced quickly to one of the most cited articles on civil conflict, and their conclusion has become a cornerstone of the literature on the economics of civil conflict (e.g., Collier and Hoeffler 2005; Collier, Hoeffler, and Dominic Rohner 2009; Håvard Hegre and Nicholas Sambanis 2006; Raymond Fisman and Miguel 2009).[1]

MSS's (2004) interpretation of the sub-Saharan African rainfall and civil conflict data rests on their finding of a statistically significant negative correlation between

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† To comment on this article in the online discussion forum, or to view additional materials, visit the article page at http://www.aeaweb.org/articles.php?doi=10.1257/app.3.4.215.

[1] MSS (2004) is the seventh most cited article on the topics civil conflict or civil war in history, economics, political sciences, and sociology according to the ISI Web of Knowledge http://isiwebofknowledge.com/.

civil conflict in year t and the year-on-year rainfall growth rate between $t-1$ and $t-2$. I show that this finding is driven by a (counterintuitive) significantly positive correlation between conflict in year t and rainfall levels in year $t-2$. If conflict was triggered by lower rainfall levels or negative rainfall shocks, the negative correlation found by MSS (2004) should have been due to a significantly negative correlation between conflict in t and rainfall levels in $t-1$. As civil conflict risk in MSS's data is not significantly higher following low rainfall levels or negative rainfall shocks, I argue that MSS's interpretation is an artifact of their empirical approach. The latest available datasets on rainfall and civil conflict in sub-Saharan Africa have been extended to 2009. In these data, there is no robust link between civil conflict and year-on-year rainfall growth or rainfall levels. This suggests that uncovering an effect of rainfall on civil conflict will require using more disaggregated data.

The main difference between my empirical approach and the empirical approach of MSS is that I focus on the correlation between civil conflict and current as well as lagged rainfall levels. To see why, it is useful to start with MSS's question of whether lower rainfall levels are associated with more or less civil conflict. MSS answer this question by examining the correlation between civil conflict and current as well as past year-on-year rainfall growth, while I address this question by examining the correlation between civil conflict and current as well as past rainfall levels.[2] When the question is about the effect of rainfall levels, the rainfall-level approach is preferable to the rainfall-growth approach. Another advantage of the rainfall-level approach is that it can be used to test whether MSS's rainfall-growth approach captures the effects of rainfall on civil conflict correctly.

To understand why MSS and I also reach different conclusions regarding the link between rainfall shocks and civil conflict, it is important to note that MSS's empirical approach uses year-on-year rainfall growth as a measure of rainfall shocks (MSS 2004, 733). As rainfall levels are strongly mean reverting, rainfall growth between two years t and $t-1$ may be low because of a negative rainfall shock in t or because of a positive rainfall shock in $t-1$. Put differently, because rainfall shocks are transitory, low rainfall growth may reflect negative shocks or mean reversion following positive shocks. Inferring the effect of rainfall (transitory) shocks on civil conflict from the effect of year-on-year rainfall growth may therefore be misleading.

To see these points more precisely, it is useful to consider MSS's linear-probability model linking civil conflict to rainfall. Their model predicts the probability of civil conflict $PPconflict_t$ in year t based on current and lagged year-on-year rainfall growth,

$$PPconflict_t = a^{LS}RGr_t + b^{LS}RGr_{t-1}, \tag{1}$$

where RGr_t is rainfall growth between year t and $t-1$; and a^{LS}, b^{LS} are least squares estimates. MSS find a statistically insignificant value for a^{LS} and a statistically significant, negative value for b^{LS}. They then use this finding to make inferences about the effect of rainfall levels and rainfall shocks on conflict. To examine whether

[2] Marshall B. Burke et al.'s (2009) and Halvard Buhaug's (2010) investigation of the effect of global warming on civil war risk in Africa also focuses on rainfall levels rather than rainfall growth rates.

such inferences are feasible, suppose that rainfall levels are distributed identically and independently over time. This implies that rainfall levels are strongly mean reverting, and that rainfall shocks are transitory.[3] Suppose also that the true probability of conflict, $Pconflict_t$, depends on current and lagged log rainfall levels ($\log R$):

$$Pconflict_t = \alpha_0 \log R_t + \alpha_1 \log R_{t-1} + \alpha_2 \log R_{t-2}. \tag{2}$$

If $\alpha_i > 0$ for $i = 0, 1, 2$, the probability of conflict is lower following low rainfall levels and negative rainfall shocks (lower than expected rainfall levels).[4] Now imagine running a least squares regression to predict the probability of conflict based on current and lagged year-on-year rainfall growth as in (1). The coefficients of this regression would be determined by the usual least squares orthogonality conditions: $= \mathrm{cov}(Pconflict_t - a^{LS}RGr_t - b^{LS}RGr_{t-1}, RGr_t) = \mathrm{cov}(Pconflict_t - a^{LS}RGr_t - b^{LS}RGr_{t-1}, RGr_{t-1}) = 0$. Making use of (2) and $RGr_t = \log R_t - \log R_{t-1}$ in these conditions yields

$$a^{LS} = \frac{2\alpha_0 - (\alpha_1 + \alpha_2)}{3} \text{ and } b^{LS} = \frac{(\alpha_0 + \alpha_1) - 2\alpha_2}{3}. \tag{3}$$ [5]

Hence, the least-squares estimates for a^{LS} and b^{LS} in (1) are mixtures of the parameters α_i determining the effects of rainfall levels and rainfall shocks on the probability of civil conflict in (2). As a result, the coefficients of the rainfall-growth specification in (1) are uninformative about the effect of rainfall levels or shocks, and using them to make inferences about the effect of rainfall levels or shocks may be misleading. For example, b^{LS} in (3) will be negative as long as $2\alpha_2 > \alpha_0 + \alpha_1$. Hence, b^{LS} may be negative, although lower rainfall levels and negative rainfall shocks reduce conflict at all lags, i.e., $\alpha_i > 0$ for $i = 0, 1, 2$ in (2). It is even possible that both a^{LS} and b^{LS} are negative, although lower rainfall levels and negative rainfall shocks reduce the probability of conflict at all lags. To see this, note that both coefficients in (3) will be negative if and only if $\alpha_0 - \theta < \alpha_1 < \alpha_0 + 2\theta$, where $\theta = \alpha_2 - \alpha_0$.[6] As a result, if $\alpha_2 > \alpha_0 > 0$, both current and lagged rainfall growth can enter (1) negatively, even if lower rainfall levels and negative rainfall shocks decrease the conflict probability at all lags.[7]

[3] Empirically, rainfall levels are strongly mean reverting. For example, regressing log rainfall levels on lagged log rainfall levels using MSS's data and controlling for country fixed effects, yields a system-GMM coefficient on lagged log rain of 0.17 with a standard error of 0.04. Accounting for the empirical persistence of rainfall does not affect the conclusion but complicates the coefficient formulas in (3).

[4] For an insightful theoretical analysis of the link between transitory economic shocks and civil conflict, see Sylvain Chassang and Gerard Padró i Miquel (2009).

[5] The assumption that log rain is independently and identically distributed implies that $\mathrm{cov}(Pconflict_t - a^{LS}RGr_t - b^{LS}RGr_{t-1}, RGr_t)$ simplifies to $(\alpha_0 - \alpha_1 - 2a^{LS} + b^{LS})V$, and that $\mathrm{cov}(Pconflict_t - a^{LS}RGr_t - b^{LS}RGr_{t-1}, RGr_{t-1})$ simplifies to $(\alpha_1 - \alpha_2 + a^{LS} - 2b^{LS})V$, where V is the variance of log rain. Hence, (3) can be obtained by solving $\alpha_0 - \alpha_1 - 2a^{LS} + b^{LS} = \alpha_1 - \alpha_2 + a^{LS} - 2b^{LS} = 0$ for a^{LS}, b^{LS}. In practice, one does not observe the probability of conflict but only whether there has been a conflict or not. This does not affect (3), however, see Jeffrey M. Wooldridge (2002, 454).

[6] Lagged rain growth will enter negatively if and only if $2\alpha_2 > \alpha_0 + \alpha_1$, or equivalently $\alpha_1 < 2\alpha_2 - \alpha_0 = 2\theta + \alpha_0$. Current rain growth will enter negatively if and only if $2\alpha_0 < \alpha_1 + \alpha_2$, or equivalently $\alpha_1 > 2\alpha_0 - \alpha_2 = \alpha_0 - \theta$. Combining inequalities yields $\alpha_0 - \theta < \alpha_1 < \alpha_0 + 2\theta$.

[7] $\alpha_2 > \alpha_0$ implies that $\theta > 0$, and, hence, that there are values for α_i, $i = 0, 1, 2$ that satisfy the inequality $\alpha_0 - \theta < \alpha_1 < \alpha_0 + 2\theta$. $\alpha_0 > 0$ implies that these values can all be strictly positive.

The intuition for why one may find lower year-on-year rainfall growth to be associated with greater civil conflict risk, even if negative rainfall shocks decrease conflict risk, is the following. Imagine an economy experiencing a negative rainfall shock and that this shock makes it unlikely that there is a civil conflict in the following year. Now, consider the situation in the following year. Because of last year's negative rainfall shock, civil conflict will be unlikely by assumption. Moreover, mean reversion implies that year-on-year rainfall growth will tend to be positive. Imposing the restriction that civil conflict can be related to rainfall growth only, as in (1), will therefore yield that civil conflict is less likely following positive rainfall growth. If one goes a step further and also assumes that rainfall growth is a measure of rainfall shocks, the conclusion becomes that civil conflict is less likely following positive rainfall shocks.

The bottom line is that rainfall-growth specifications as in (1) cannot be used to make inferences about the effect of rainfall levels or rainfall shocks on civil conflict, as a negative correlation between conflict and lagged year-on-year rainfall growth may not reflect higher civil conflict risk following lower rainfall levels or negative rainfall shocks. This concern turns out to be justified in MSS's data, as their finding of a negative correlation between civil conflict and year-on-year rainfall growth between $t-1$ and $t-2$ is driven by a (counterintuitive) positive correlation between conflict and rainfall levels in year $t-2$.

Another advantage of rainfall-level specifications as in (2) is that they nest rainfall-growth specifications. This allows using rainfall-level specifications to test the restrictions implicit in rainfall-growth specifications. For example, suppose the probability of civil conflict was in fact determined by lagged year-on-year rainfall growth,

$$Pconflict_t = \beta RGr_{t-1} = \beta(\log R_{t-1} - \log R_{t-2}) \text{ with } \beta < 0, \tag{4}$$

as suggested by MSS's (2004) findings. This rainfall growth specification is equivalent to the rainfall-level specification

$$Pconflict_t = \beta \log R_{t-1} - \beta \log R_{t-2} \text{ with } \beta < 0. \tag{5}$$

Hence, the rainfall-growth specification in (4) implies a negative coefficient on $t-1$ rainfall in a rainfall-level specification. This is quite intuitive: if high civil conflict risk was in fact caused by falling rainfall between $t-2$ and $t-1$, lower $t-1$ rainfall should be associated with greater civil conflict risk when $t-2$ rainfall is held constant. Rejection of the hypothesis that $t-1$ rainfall enters negatively in a rainfall-level specification implies rejection of the rainfall-growth specification in (4). I find that the data reject the hypothesis that $t-1$ rainfall enters negatively in a rainfall-level specification and threfore also reject the rainfall-growth specification in (4).

While the growth specification in (1) does not allow uncovering whether civil conflict is caused by transitory (rainfall) shocks, it can be used to examine whether conflict is caused by permanent shocks. To see this, suppose that the driving variable $\log x_t$ follows a random walk $\log x_t = \log x_{t-1} + \varepsilon_t$, where ε_t is distributed identically and independently over time and has mean zero. In this case, year-on-year growth of the driving variable $\log x_t - \log x_{t-1}$ is equal to the (permanent) shock

ε_t. Hence, the effect of shocks on civil conflict can be uncovered using a growth specification. This is why examining the link between conflict and commodity price shocks, which are typically very persistent (see Paul Cashin, Hong Liang, and C. John McDermott (2000) and Markus Brückner and Ciccone (2010)), requires a different approach than examining the link between conflict and rainfall shocks.

The remainder of the paper examines the link between rainfall and civil conflict using the dataset employed by MSS as well as the latest available data. Additional empirical results can be found in an online Appendix.

I. Does Civil Conflict Follow Lower Rainfall Levels or Negative Rainfall Shocks?

The conflict data come from the UCPD/PRIO Armed Conflict Database.[8] The rainfall data come from the Combined Precipitation Dataset of NASA's Global Precipitation Climatology Project (GPCP; these data are only available since 1979).[9]

UCPD/PRIO defines conflict as "a contested incompatibility which concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths." MSS's (2004) definition of civil conflict includes all internal armed conflicts without any intervention from other states and all internal armed conflicts with intervention from other states. MSS consider there to be a civil conflict in a country if there is a civil conflict on the country's own territory or if the country participates in a civil conflict in another country. Peter Sandholt Jensen and Kristian Skrede Gleditsch (2009) exclude participation in extraterritorial civil conflicts to focus on the determinants of civil conflicts fought on the country's own territory. For results excluding extraterritorial civil conflicts, see the online Appendix.

I report results on the link between rainfall and either civil conflict onset or conflict incidence. Civil conflict onset is an indicator variable that captures conflict outbreak. The onset indicator in year t is 1 if there is a civil conflict in t but there was no conflict in $t-1$; 0 if there is no conflict in t and there was no conflict in $t-1$; and not defined if there was a conflict in $t-1$. Conflict incidence, on the other hand, is an indicator variable that is 1 if there is a conflict in t and 0 if there is not. Hence, the conflict incidence indicator may be 1 because of the outbreak of a new conflict or the continuation of an existing conflict. Rainfall in year t is calculated as average annual rainfall.

All tables report two standard errors for each least squares estimate. The standard errors in parentheses are consistent for arbitrary heteroskedasticity and time-series correlation within each country cluster. The standard errors in square brackets also make a small sample adjustment. The statistical theory behind hypothesis tests using the small sample adjusted standard errors assumes normally distributed and homoskedastic residuals (e.g., William H. Greene 1990, 161). Both the normality assumption and the homoskedasticity assumption are violated in (my) linear probability models, where the left-hand-side variable is either 0 or 1 (e.g., Wooldridge 2002). I report

[8] See Nils Petter Gleditsch et al. (2002). For the conflict data, see http://www.prio.no/CSCW/Datasets/Armed-Conflict/UCDP-PRIO/.

[9] Which, in contrast to the datasets covering the period before 1979, employs both gauge and satellite measurements. See Robert F. Adler et al. (2003) and http://precip.gsfc.nasa.gov.

standard errors incorporating the small sample adjustment to facilitate comparison with MSS (2004) and Miguel and Satyanath (2010).

The empirical results reported in the paper are based on least squares regressions and, following MSS (2004), control for country-specific intercepts and country-specific linear time trends. For results controlling for common time-varying shocks to conflict risk see the online Appendix. MSS (2004) also present instrumental variables results. These are subject to the same issues as their least squares results, see Ciccone (2011a), and therefore not discussed separately here.

A. *Civil Conflict Onset* (*Outbreak*)

I first examine the link between rainfall and civil conflict onset in MSS's (2004) data, and then turn to the latest versions of the databases employed by MSS.

Conflict Onset and Rainfall in MSS's (*2004*) *Data*.—Table 1, columns 1 and 2 contain results using MSS's (2004) data for the 1979–1999 period, which come from UCPD/PRIO and the GPCP. (As MSS control for contemporaneous and lagged year-on-year rainfall growth and the GPCP rainfall data start in 1979, the earliest civil conflict onset observations employed correspond to 1981.) Column 1 shows that a least squares regression of conflict onset in year t on current and lagged year-on-year rainfall growth yields a significantly negative coefficient on year $t-1$ rainfall growth (year-on-year rainfall growth between $t-1$ and $t-2$). The coefficient on $t-1$ rainfall growth is significant at the 90 percent confidence level, no matter which standard error is used. Does this empirical result imply that conflict onset is more likely following lower rainfall levels or negative rainfall shocks? This question can be answered by regressing conflict onset on current and lagged log rainfall levels as in column 2. This yields that conflict onset is less likely following lower $t-2$ rainfall levels and negative $t-2$ rainfall shocks. The estimate indicating that conflict onset is less likely following lower rainfall levels and negative rainfall shocks is significant at the 95 percent confidence level, no matter which standard error is used.

Conflict Onset and Rainfall in the Latest Data.—The latest UCDP/PRIO conflict dataset, the Armed Conflict Database Version 4-2010,[10] contains conflict data until 2009. The latest version of the GPCP rainfall dataset, the Combined Precipitation Dataset Version 2.1,[11] contains rainfall data until September 2009. These datasets allow me to examine the link between rainfall and civil conflict onset for the 1979–2009 period. It seems unlikely that the lack of rainfall data for the last three months of 2009 will affect results substantially. For this to be the case, civil conflicts starting at the end of 2009 would have to be caused by rainfall in the last three months of the year. This seems improbable, especially as the empirical results in Table 1 indicate that contemporaneous, annual rainfall levels do not affect civil conflict risk. In any

[10] See UCDP/PRIO Armed Conflict Dataset Version 4-2010, Version History and Known Errata (2010).
[11] See George J. Huffman and David T. Bolvin (2009).

Table 1—Rainfall and Civil Conflict Onset

	MSS (2004) data, which are for 1979–1999		Latest data, which are for 1979–2009	
	(1)	(2)	(3)	(4)
Rainfall growth, t	−0.063 (0.044) [0.048]		−0.037 (0.029) [0.031]	
Rainfall growth, $t-1$	−0.120* (0.062) [0.068]		−0.052 (0.033) [0.036]	
Log rainfall, t		−0.073 (0.078) [0.086]		0.005 (0.041) [0.044]
Log rainfall, $t-1$		−0.026 (0.069) [0.075]		0.023 (0.042) [0.044]
Log rainfall, $t-2$		0.156** (0.068) [0.074]		0.074 (0.052) [0.056]
Country FE and trend	Yes	Yes	Yes	Yes
Observations	555	555	873	873

Notes: The dependent variable is an indicator variable capturing civil conflict onset (see page 219). The method of estimation is least squares. Standard errors in parentheses are robust for arbitrary heteroskedasticity and clustered at the country level. Standard errors in square brackets also apply the STATA small sample adjustment (see page 219). When the asterisks are next to the least squares point estimate, the confidence level applies no matter which of the two standard errors is employed. When the asterisks are next to the standard error, the confidence level applies to that standard error only.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

case, I will also comment on the results for the 1979–2008 period (which are similar to results for 1979–2009; see the online Appendix).[12]

Table 1, columns 3 and 4 show that according to the latest data there is no significant link between civil conflict onset and rainfall levels or rainfall growth.[13] This continues to be the case when I control for shocks to the probability of civil conflict onset that are common to all sub-Saharan African countries,[14] and when I focus on the 1979–2008 period.[15] When I control for rainfall and temperature, there is some evidence that civil conflict onset over the 1979–2008 period is less likely following low rainfall levels and negative rainfall shocks.[16]

[12] The full set of 1979–2008 results are in online Appendix II.
[13] Nor is there evidence of statistically significant effects of rainfall growth.
[14] See online Appendix Tables I.B.1 and I.C.1, panel B, columns 3–4 and 7–8.
[15] See online Appendix Tables II.A.1, II.B.1, and II.C.1, columns 3–4 and columns 7–8.
[16] See online Appendix Table III.A. The 1979–2008 temperature data used come from Buhaug, Hegre, and Strand (2010). But the link between rainfall and civil conflict is not robust to using the 1981–2002 temperature data of Burke et al. (2009); see online Appendix Table III.C.

B. *Civil Conflict Incidence*

I now turn to the link between rainfall and civil conflict incidence. Civil conflict incidence subsumes conflict onset (outbreak) and conflict continuation. Hence, the implicit assumption when using conflict incidence instead of conflict onset as the dependent variable is that rainfall affects conflict onset and conflict continuation in the same way.

Conflict Incidence and Rainfall in MSS's (2004) Data.—I first use the UCPD/PRIO and GPCP datasets for 1979–1999 employed by MSS (2004) to reproduce their result that regressing civil conflict incidence on current and lagged year-on-year rainfall growth yields a least squares coefficient of −0.063 on rainfall growth at t and of −0.122 on rainfall growth at $t - 1$. Rainfall growth at t enters statistically insignificantly, while $t - 1$ rainfall growth is statistically significant at the 95 percent confidence level whether or not the small sample adjustment of standard errors based on normally distributed and homoskedastic residuals is used. Table 2, columns 1 and 2 add lagged incidence to MSS's specification as the probability of civil conflict may depend on whether there already was a conflict in the previous year. Column 1 reports least squares results, while column 2 reports system-GMM results.[17] Not surprisingly, there is significant persistence in conflict incidence—civil conflict is 28 percentage points more likely when there was a conflict in the previous year.

Does the negative coefficient on lagged rainfall growth in the civil conflict incidence regressions in columns 1 and 2 imply that conflict incidence is associated with lower rainfall levels or that conflict follows negative rainfall shocks? The statistically significant estimates in columns 3 and 4 shed doubt on such a conclusion. Relating civil conflict incidence to current and lagged log rainfall levels yields that conflict is less likely following lower $t - 2$ rainfall, and that the coefficient on $t - 2$ rainfall is statistically significant at the 90 percent confidence level according to the system-GMM result and the least squares result with and without the small sample adjustment. The results in columns 3 and 4 also imply that civil conflict incidence is less likely following negative rainfall shocks.[18]

Conflict Incidence and Rainfall in the Latest Data.—Table 2, columns 5–8 examine the link between civil conflict incidence and rainfall over the 1979–2009 period

[17] Least squares is inconsistent for a fixed time-series dimension (number of years), while system-GMM is consistent as the cross-sectional dimension goes to infinity, even when the number of years is fixed, see Wooldridge (2002, 304). There is no small sample adjustment for system-GMM, which is why only one standard error is reported for these results.

[18] Miguel and Satyanath (2010) find a statistically insignificant effect of rainfall levels on conflict incidence using MSS's datasets. The explanation for the discrepancy with the results in Table 2 is that my sample has 743 observations just like MSS's sample, while Miguel and Satyanath (2010) lose 41 observations. The reason why Miguel and Satyanath lose 41 observations is best illustrated with an example. The first observation in MSS (2004) for Nigeria relates civil conflict incidence in 1981 to rainfall between 1981 and 1979 (their rainfall data only starts in 1979). To keep this observation when controlling for lagged civil conflict incidence, one has to use data on civil conflict incidence in Nigeria in 1980 from the UCDP/PRIO Armed Conflict Database Version 1.2a employed by MSS (2004). I use these data and keep the observation, while Miguel and Satyanath (2010) do not use these data and lose this observation. The result is that Miguel and Satyanath (2010) lose one observation for each of the 41 countries in MSS's (2004) sample.

Table 2—Rainfall and Civil Conflict Incidence

	MSS (2004) data, which are for 1979–1999				Latest data, which are for 1979–2009			
	LS (1)	GMM (2)	LS (3)	GMM (4)	LS (5)	GMM (6)	LS (7)	GMM (8)
Rainfall growth, t	−0.025 (0.040) [0.043]	−0.017 (0.043)			−0.044 (0.048) [0.050]	−0.047 (0.05)		
Rainfall growth, $t-1$	−0.129** (0.048) [0.051]	−0.123** (0.049)			−0.04 (0.034) [0.036]	−0.045 (0.038)		
Log rainfall, t			−0.053 (0.060) [0.065]	−0.033 (0.063)			0.04 (0.067) [0.071]	0.039 (0.07)
Log rainfall, $t-1$			−0.102 (0.069) [0.074]	−0.094 (0.066)			0.059 (0.048) [0.051]	0.061 (0.05)
Log rainfall, $t-2$			0.128* (0.067) [0.072]	0.125* (0.064)			0.076 (0.044)* [0.046]	0.084* (0.05)
Lagged incidence	0.277*** (0.077) [0.083]	0.282*** (0.077)	0.274*** (0.078) [0.084]	0.280*** (0.078)	0.369*** (0.057) [0.06]	0.369*** (0.057)	0.367*** (0.055) [0.058]	0.367*** (0.055)
Country FE and trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	743	743	743	743	1,179	1,179	1,179	1,179

Notes: The dependent variable is an indicator variable capturing civil conflict incidence (see page 219). The method of estimation is least squares or system-GMM. Standard errors in parentheses are robust for arbitrary heteroskedasticity and clustered at the country level. Standard errors in square brackets also apply the STATA small sample adjustment (see page 219). When the asterisks are next to the least squares point estimate, the confidence level applies no matter which of the two standard errors is employed. When the asterisks are next to the standard error, the confidence level applies to that standard error only.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

using the UCDP/PRIO Armed Conflict Database Version 4-2010 and the GPCP Combined Precipitation Dataset Version 2.1. Columns 5 and 6 show that in these data there is no statistically significant link between civil conflict incidence on the one hand and current and lagged year-on-year rainfall growth on the other. Moreover, the latest data do not support the hypothesis that civil conflict incidence follows lower rainfall levels or negative rainfall shocks. If anything, the statistically significant coefficients in columns 7 and 8 point in the opposite direction. But these coefficients turn insignificant when I consider the 1979–2008 period (to avoid employing the rainfall data for 2009, which is based on January to September rainfall only); when I follow Jensen and Gleditsch (2009) and focus on civil conflict on countries' own territory; or when I control for shocks to the probability of civil conflict onset that are common to all sub-Saharan African countries.[19] The data continue to reject the

[19] See online Appendix Table II.A.4, panel A, columns 8–10; online Appendix Table I.A.3, panel B, columns 8–10; and online Appendix Table I.C.3, panel A, columns 8–10.

hypothesis that conflict incidence follows lower rainfall levels or negative rainfall shocks when I control for shocks to the probability of civil conflict that are common to all sub-Saharan African countries,[20] and when I focus on the 1979–2008 period.[21] This continues to be the case when I also account for temperature.[22]

II. Civil War and Rainfall in the Latest Data

UCPD/PRIO defines civil war as a civil conflict with more than 1,000 annual battle-related casualties (UCDP/PRIO Armed Conflict Dataset Codebook 2010).[23] Table 3 examines the link between rainfall and civil war onset and incidence using the 1979–2009 data from the UCDP/PRIO Armed Conflict Database Version 4-2010 and the GPCP Combined Precipitation Dataset Version 2.1. Results should be interpreted with caution, however, as the 1,000 casualties threshold is arbitrary and may be inappropriate for sub-Saharan Africa.[24]

Column 1 shows that a least squares regression of war onset in year *t* on current and lagged rainfall growth yields a significantly negative coefficient on rainfall growth in *t*. The coefficient is significant at the 90 percent confidence level, no matter which standard error is used. The corresponding rainfall-level specification in column 4 shows that this result cannot be interpreted as civil war onset being more likely following low rainfall levels or negative rainfall shocks. According to the results in column 4, civil war onset is either unrelated to rainfall levels and shocks or significantly less likely following low rainfall levels and negative rainfall shocks in $t - 1$, depending on the standard error used. It is worth noting that the statistically significant coefficients in column 1 and 4 turn insignificant when I follow Jensen and Gleditsch (2009) and focus on civil wars on countries' own territory, or when I control for shocks to the probability of civil war onset that are common to all sub-Saharan African countries.[25] The table also shows that there is no statistically significant link between rainfall levels or rainfall shocks and civil war incidence. These results continue to hold when I control for shocks to the probability of civil war that are common to all sub-Saharan African countries,[26] and when I focus on the 1979–2008 period and control for temperature.[27]

[20] See online Appendix Tables I.B.3 and I.C.3, panel A, columns 8–10.

[21] See online Appendix Table II.A.2, II.B.2, and II.C.2, panel A, columns 8–10.

[22] See online Appendix Table III.B for 1979–2008 and online Appendix Table III.D for 1981–2002.

[23] MSS (2004) point out that the particular threshold chosen is arbitrary and Buhaug (2010) that the threshold may affect empirical results. Civil war results should therefore be interpreted with caution.

[24] Because there are many small countries, see MSS (2004), and Miguel, Satyanath, and Sergenti (2007).

[25] See online Appendix Table I.A.4, panel B, columns 5–8 and online Appendix Table I.C.4, panel B, columns 1–4.

[26] See online Appendix Tables I.B.4 and I.C.4, panel B, columns 3–4 and Tables I.B.6 and I.C.6, panel A, columns 8–10.

[27] See online Appendix Tables II.A.3, II.B.3, and II.C.3, columns 3–4 and online Appendix Tables II.A.4, Table II.B.4, Table II.C.4, panel A, columns 8–10. The 1979–2008 results controlling for temperature are in online Appendix Tables III.A and III.B. When I use the 1981–2002 temperature data of Burke et al. (2009) there is some evidence that civil war is less likely following low rainfall levels and negative rainfall shocks, see online Appendix Tables III.C and III.D.

Table 3—Rainfall and Civil War Onset or Incidence 1979–2009

	Onset LS (1)	Incidence LS (2)	Incidence GMM (3)	Onset LS (4)	Incidence LS (5)	Incidence GMM (6)
Rainfall growth, t	−0.036*	−0.047	−0.055			
	(0.019)	(0.030)	(0.034)			
	[0.020]	[0.031]				
Rainfall growth, $t-1$	0.004	−0.017	−0.024			
	(0.018)	(0.022)	(0.024)			
	[0.019]	[0.023]				
Log rainfall, t				−0.029	−0.039	−0.048
				(0.03)	(0.045)	(0.053)
				[0.032]	[0.047]	
Log rainfall, $t-1$				0.051	0.039	0.038
				(0.03)*	(0.032)	(0.032)
				[0.032]	[0.034]	
Log rainfall, $t-2$				−0.006	0.02	0.024
				(0.026)	(0.035)	(0.04)
				[0.026]	[0.036]	
Lagged incidence		0.415***	0.415***		0.416***	0.416***
		(0.051)	(0.051)		(0.051)	(0.051)
		[0.054]			[0.054]	
Country FE and trend	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,036	1,179	1,179	1,036	1,179	1,179

Notes: The dependent variable is an indicator variable capturing civil war onset or incidence (see page 219). The method of estimation is least squares or system-GMM. Standard errors in parentheses are robust for arbitrary heteroskedasticity and clustered at the country level. Standard errors in square brackets also apply the STATA small sample adjustment (see page 219). When the asterisks are next to the least squares point estimate, the confidence level applies no matter which of the two standard errors is employed. When the asterisks are next to the standard error, the confidence level applies to that standard error only.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

III. Conclusion

Two of the conclusions of MSS's (2004) study of civil conflict and rainfall in sub-Saharan Africa are that lower rainfall levels and adverse rainfall shocks increase conflict risk. These conclusions rest on their finding of a negative correlation between conflict in year t and year-on-year rainfall growth between $t-1$ and $t-2$. I argue that such a negative correlation between conflict and lagged year-on-year rainfall growth may not reflect that civil conflict risk is higher following lower rainfall levels or adverse rainfall shocks. This concern turns out to be justified in MSS's data, as the negative correlation between civil conflict and year-on-year rainfall growth between $t-1$ and $t-2$ found by MSS is driven by a (counterintuitive) positive correlation between civil conflict and rainfall levels in year $t-2$. If civil conflict was triggered by lower rainfall levels or negative rainfall shocks, the negative correlation found by MSS should have been due to a negative correlation between civil conflict in t and rainfall levels in $t-1$.

The latest available datasets on rainfall and civil conflict in sub-Saharan Africa have been extended to 2009. In these data, there is no robust link between civil conflict and year-on-year rainfall growth or rainfall levels. This suggests that uncovering an effect of rainfall on civil conflict risk will require using more disaggregated data.

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