Climate Change, Agricultural Production and Civil Conflict: Evidence from the Philippines

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Abstract

Climate change is predicted to affect global rainfall patterns, but there is mixed evidence with regard to the effect of rainfall on civil conflict. Even among researchers who argue that rainfall reduces civil conflict, there is disagreement as to the underlying mechanism. Using data from the Philippines for the period 2001-2009, we exploit seasonal variation in the relationship between rainfall and agricultural production to explore the connection between rainfall and civil conflict. In the Philippines, above-average rainfall during the wet season is harmful to agricultural production, while above-average rainfall during the dry season is beneficial. We show that the relationship between rainfall and civil conflict also exhibits seasonality, but in the opposite direction and with a one-year lag. Consistent with the hypothesis that rebel groups gain strength after a bad harvest, there is evidence that lagged rainfall affects the number of violent incidents initiated by insurgents but not the number of incidents initiated by government forces. Our results suggest that policies aimed at mitigating the effect of climate change on agricultural production could weaken the link between climate change and civil conflict.

Keywords: Climate Change, Civil Conflict, Rainfall

JEL Classification: O13, H56, D74

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1 Introduction

Climate change poses multiple threats to national security, global stability and human welfare (IPCC, 2014; Department of Defense, 2014; USAID, 2014). One of these threats takes the form of reduced rainfall, which is expected to spark civil conflict in developing countries (IPCC, 2014, pp. 772-779). However, despite its importance, the link between changing rainfall patterns and conflict is not well understood (Nardulli et al., 2015; USAID, 2009, 2014).

The empirical evidence on the effects of rainfall on conflict has been decidedly mixed (Theisen et al., 2013). For instance, using data on sub-Saharan African countries, Miguel et al. (2004) and Miguel and Satyanath (2011) found that rainfall spurs economic growth, which in turn reduces the risk of civil conflict. In contrast, Hendrix and Salehyan (2012) found that abnormally wet years are associated with more civil conflict, while Burke et al. (2009) and Buhaug (2010) found little evidence of a relationship between rainfall and civil conflict in sub-Saharan Africa.

Even among researchers who have found an effect of rainfall on conflict, there is disagreement as to the underlying mechanism. Some researchers have argued that rainfall is related to civil conflict through agricultural production (Miguel et al., 2004; Miguel and Satyanath, 2011; Maystadt and Ecker, 2014; Couttenier and Soubeyran, 2014). Alternatively, rainfall could have direct psychological effects on combatants, or be related to civil conflict through its impact on roads, bridges and the availability of surface water (Witsenburg and Adano, 2013; Ciucci et al., 2011; Hiltunen et al., 2012; Sarsons, 2013; Hsiang and Burke, 2014).[1]

[1] After studying pastoralists and farmers from northern Kenya for several years, Witsenburg and Adano (2009, p. 520) concluded:

> When a drought is expected, warring communities often reconcile in order to use water and pasture together. On the other hand, violent livestock raiding is mostly done during wet years: then, the livestock is stronger and fatter, and vegetation and surface water are more readily

Disentangling these mechanisms is crucial to informing policy responses to climate change (Burke et al., 2015). Even under the most optimistic scenarios, substantial climate change appears to be unavoidable (IPCC, 2014, p.189), and designing policies that can increase societal resilience against civil conflict in the face of a changing climate will become increasingly important (World Bank, 2012; Center for Naval Analyses, 2014; USAID, 2014).

Using data on civil conflict in the Philippines for the period 2001-2009, we exploit seasonal variation in the effect of rainfall on agricultural production to gain a better understanding of the mechanisms through which rainfall affects conflict. In the Philippines, above-average rainfall during the wet season (May through October) is harmful to agricultural production, while above-average rainfall during the dry season (November-April) is beneficial (Lansigan et al., 2000; Gerpacio et al., 2011; Roberts et al., 2009). We hypothesize that, if agricultural production is in fact the mechanism through which rainfall affects civil conflict, then the relationship between rainfall and civil conflict should also exhibit seasonality but in the opposite direction and with a one-year lag.

We begin our analysis by using annual data on corn and rice harvests at the province level to confirm that the effect of rainfall on agricultural production exhibits the expected seasonality. Next, lending support to the argument that rainfall is related to civil conflict through agricultural production, we show that above-average rainfall in the wet season of the previous year is associated with more conflict, while above-average rainfall in the dry season of the previous year is associated with less conflict. This pattern of results is especially pronounced in rice-producing provinces; where corn is the primary crop, and in provinces with relatively little land under cultivation, the relationship between lagged rain and conflict does not exhibit as much seasonality. Consistent with the hypothesis that rebel groups gain

available, which is necessary during a long trek. The vegetation is also thicker which makes it easier to hide after an attack. Raiders usually have to trek long distances for which the animals should be fit and strong.

strength after a bad harvest, we find evidence that lagged rainfall affects the number of violent incidents initiated by insurgents but not the number of incidents initiated by government forces. Finally, we find that most of the violence attributable to rainfall is directed at civilians, although violence directed at government forces is also affected.

Our findings have important implications for policymakers interested in anticipating and bolstering societal resilience to conflict as the climate changes. Specifically, our findings suggest that policies aimed at reducing the effect of climate change on agricultural production could weaken the link between climate change and civil conflict. In addition, they provide evidence for a link between rainfall and conflict using data from the densely populated region of Southeast Asia in a literature that has, thus far, focused almost exclusively on sub-Saharan Africa. Finally, our findings highlight the importance of looking beyond annual rainfall totals when estimating the effect of climate change on civil conflict. Climate models predict that in the Philippines and other parts of Southeast Asia, the wet season will become wetter while the dry season will become drier (Christensen et al., 2007; Asian Development Bank, 2009; B. and S., 2009). Our results suggest that not accounting for seasonal variation in the relationship between rainfall and agricultural production could lead to an underestimate of the effect of climate change on civil conflict in the region.

2 Background

2.1 Previous literature on rainfall and conflict

Research on the relationship between rainfall and civil conflict has generally focused on Africa (Miguel et al., 2004; Burke et al., 2009; Buhaug, 2010; Miguel and Satyanath, 2011; Hendrix and Salehyan, 2012; O'Loughlin et al., 2012; Theisen, 2012). However, observers have argued that climate change is likely to intensify several on-going conflicts, and lead to new conflicts, in Southeast Asia (Smith, 2007; Jasparro and Taylor, 2008; Gerstl and Helmke, 2012; Jasparro and Taylor, 2011).

Indeed, as climate change progresses, many parts of Southeast Asia are likely to receive more precipitation in the rainy season and less precipitation in the dry season (Christensen et al., 2007; Asian Development Bank, 2009; B. and S., 2009). Unless new varieties of rice with resistance to heat and water stress are developed (or other technological solutions are adopted), rice yields in Southeast Asia will decline substantially (Lansigan et al., 2000; Fischer et al., 2005; Lansigan, 2005; Asian Development Bank, 2009; Ahmed and Suphachalasai, 2014). It is an open question whether this decline in rice yields will lead to more civil conflict.

Only one previous study has examined the relationship between rainfall and civil conflict in Asia. Using data for the period 1950-2008, Wischnath and Buhaug (2014) found little evidence that civil conflict is sparked by lack of rain, perhaps because Asian economies and/or farmers are less reliant on traditional agricultural practices than their African counterparts. Although Wischnath and Buhaug (2014) concluded that the onset of civil conflict in Asia is unrelated to rainfall and drought, they noted that climate "may shape the severity, duration, and geographic spread of hostilities" (p. 719).

There are a number of reasons why rainfall could prolong or intensify ongoing civil conflicts. While agricultural production is perhaps the most frequently cited mechanism in the literature, other explanations have been suggested. It is, for example, possible that heavy rainfall makes roads and bridges impassable, thereby increasing the cost of carrying out long-distance attacks or impeding state security efforts (Sarsons, 2013; Hsiang and Burke, 2014; Fearon and Laitin, 2003). In addition, above-average rainfall could increase the density of vegetation, allowing combatants to conceal their activities (Witsenburg and Adano, 2013). The mechanism through which rainfall affects conflict has important implications for the optimal policy responses to climate change. If agriculture is the link between rainfall and conflict, policies aimed at reducing the effect of rainfall shocks on crop yields are likely to increase societal resilience to conflict in the face of climate change. These policies include investments in irrigation, crop diversification and breeding programs for increased resistance to water stress. If, on the other hand, infrastructure and/or vegetation density explain the relationship between rainfall and civil conflict, then such policies will have little impact on societal resilience.

Two previous studies have explored whether the relationship between rainfall and civil conflict is attributable to agricultural production. Using data from Africa, Harari and La Ferrara (2014) found that weather shocks (such as above-average temperatures or below-average rainfall) during the growing season had a larger impact on conflict-related incidents than weather shocks outside of the growing season.

Sarsons (2013) noted that agricultural production downstream from dams is more likely to depend on irrigation as compared to upstream production. She hypothesized that the effect of rainfall on conflict should, therefore, be less pronounced in downstream districts. Using data from India, Sarsons found little evidence for this hypothesis. In fact, the relationship between rainfall and conflict (as measured by riots between Hindus and Muslims) was strongest in downstream districts, suggesting the existence of a mechanism distinct from agricultural production.[2]

Our empirical strategy is inspired by Harari and La Ferrara (2014) and Sarsons (2013). We hypothesize that if rainfall were related to conflict through infrastructure (by, for instance, increasing the cost of travel), then its effect should be immediate, negative and more pro-

[2] Bollfrass and Shaver (2013) followed a similar logic by separately estimate the effect of temperature on conflict in regions with and without significant agricultural production. They found that the positive association between temperature and conflict was as strong in non-agricultural as in agricultural regions and interpreted this pattern of results as evidence of a psychological mechanism.

nounced during the wet, as opposed to the dry, season. Our results, however, provide little evidence of an immediate, negative effect of wet-season rainfall. Instead, above-average rainfall in the wet season is associated with an increase in conflict one year later, while above average-rainfall in the dry season is associated with a much weaker decrease in conflict one year later. These results are difficult to reconcile with the infrastructure hypothesis, but are easily explained by the well-documented seasonality (Lansigan et al., 2000; Gerpacio et al., 2011; Roberts et al., 2009) in the relationship between rainfall and Philippine agricultural production.

2.2 Agriculture and rainfall in the Philippines

Agriculture is an important part of Philippine economy, employing 35 percent of workers and generating 13 percent of GDP in 2009 (*World Development Indicators*, 2015). The most important crop is rice, which is the main source of income and employment for 11.5 million farming households (Sebastian et al., 2000). Rice supplies 35 percent of caloric intake for the average household, and 60-65 percent of caloric intake for households in the lowest income quartile (David and Balisacan, 1995). In 2002, 42 percent of land under cultivation was planted in rice. The second most important grain crop in the Philippines is corn, which accounted for 25 percent of the land under cultivation. Unlike rice, which is almost exclusively grown as a food crop, corn is mostly used as feed for livestock (Gerpacio et al., 2011).

There are two growing seasons in the Philippines, a wet season that lasts approximately from May to October and a dry season from November to April (Lansigan et al., 2000). In the wet season, the greatest risk to crops is flooding and extreme weather events such as typhoons; as a consequence, above-average rainfall in this season is associated with lower agricultural production (Lansigan et al., 2000; Gerpacio et al., 2011; Roberts et al., 2009). In the dry season, the greatest risk to crops is drought; above-average rainfall in this season is associated with higher agricultural production (Roberts et al., 2009). Below, using annual data on corn and rice harvests at the province level from the Philippine Bureau of Agricultural Statistics, we confirm that the relationship between rainfall and agricultural production exhibits the expected seasonality.

2.3 Civil Conflict in the Philippines

The Philippines is involved in two distinct on-going civil conflicts during the period examined by this study, which together have caused more than 120,000 deaths (Schiavo-Campo and Judd, 2005). The most geographically widespread of these conflicts involves the New People's Army (NPA), a Maoist guerilla group founded in 1969 that seeks to overthrow the Philippine government and replace it with a communist system. In 2005, the mid-point of this study, the NPA was estimated to have 7,100 fighters (Felter, 2005). The NPA operates primarily in rural areas and relies on support from the rural poor, who supply most of its labor and logistics.

The second on-going conflict involves the Moro Islamic Liberation Front (MILF), a separatist movement fighting for an independent state in the predominantly Muslim areas of Mindanao Island and the Sulu archipelago. The MILF was formed in 1984, when the group's founders defected from the Moro National Liberation Front (MNLF). After this split, the MILF pursued a strategy of armed conflict against the government, while the MNLF signed a peace agreement in 1996 that created the Autonomous Region of Muslim Mindanao (ARRM). The MILF enjoys broad-based support among Muslims in the Philippines (Kreuzer and Werning, 2007). With an estimated 10,500 fighters, the MILF is larger than the NPA, but has a much narrower geographic reach.

In addition to the NPA and MILF, the Armed Forces of the Philippine (AFP) must also contend with the Abu Sayyaf Group (ASG) and so-called "Lawless Elements". The ASG is a high-profile Philippine terrorist organization with suspected links to al-Qaeda that mostly operates on Basilan Island and in the remote Sulu Archipelago in the far southwest of the country. While ASG receives considerable media attention, it has a far smaller number of fighters than NPA and MILF and is responsible for only a small fraction of the violence recorded in our dataset. The term "Lawless Elements" refers to small, loosely-allied bands of guerrilla and criminal groups operating across the Philippines. Some of these groups are led by former NPA, MILF or ASG commanders who broke away from the main organization. Many of them employ guerrilla-like tactics but use violence primarily as part of criminal activities such as extortion or kidnapping for ransom rather than to pursue political objectives.

3 Data

Our analysis is at the province-year level. Province boundaries are from 2001, when the Philippines was divided into seventy-nine provinces, each administered by a separate governor and legislative assembly. Three provinces, all located in the remote Sulu Archipelago (Basilan, Sulu and Tawi-Tawi), were not included in the analysis. The climate of the Sulu Archipelago differs markedly from the rest of the country and does not feature pronounced rainfall seasonality. Another province, Batanes, was excluded from the analysis because of missing information on agricultural production, most likely due to its small size and remote location. Of the remaining 75 provinces, 73 contributed 9 years of data (2001-2009) to the analysis; two provinces (Zamboanga Sibugay and Compostela Valley) contributed 8 years of data because of missing information on agricultural production in 2001.

Data on agricultural production come from the Philippine Bureau of Agricultural Statistics and are publicly available through the CountryStat database.[3] The rainfall measurements for each province were constructed using the Tropical Rainfall Measuring Mission's 3B43 algorithm, which produces estimates of monthly precipitation using a weighted combination of various microwave satellite estimates and rain gauge estimates.[4] The TRMM dataset was selected for its high degree of spatial resolution. Monthly precipitation averages are estimated for a 0.25x0.25 degree latitude and longitude grid, providing a higher spatial resolution than most global precipitation data sets. Each province's precipitation value was constructed by overlaying province boundaries on the 0.25x0.25 degree grid and calculating a weighted mean of precipitation by area.

Our measures of conflict intensity are based on incident reports from Philippine military units operating in the field during the period 2001-2009. These reports were originally collected by Felter (2005) and have been updated through 2009. They were used by Berman et al. (2011) and Crost et al. (2014) to study the determinants of conflict in the Philippines. Because the reports were used by the armed forces to plan operations and were not originally intended for public release, they are an unusually reliable source of information on the civil conflict (Berman et al., 2011; Crost et al., 2014). They include information on which group (the government or the insurgents) initiated the incident, the number combatants killed, and the number of civilians killed.

We calculated two measures of conflict intensity from these data. The first is equal to the number of casualties by province and year. The second is equal to the number of violent incidents, defined as incidents resulting in at least one casualty. Regressions using this latter measure are less likely to be influenced by outliers because they give less weight to single incidents with above-average casualty counts.

[3] `http://countrystat.bas.gov.ph/`. This website was last accessed in February of 2015.

[4] Details are available at `http://mirador.gsfc.nasa.gov/collections/TRMM_3B43__007.shtml`. Site last accessed February 2015.

4 Empirical Strategy

Our empirical strategy exploits the seasonal pattern of rainfall in the Philippines. Specifically, we allow rainfall and conflict to have different effects in the wet versus the dry season. Our estimating equation for agricultural production is:

$$Y_{it} = \beta_0 + \beta_1 R_{it}^{total} + \beta_2 R_{it}^{wet} + \alpha_i + \lambda_i t + \varepsilon_{it} \tag{1}$$

where Y_{it} denotes the natural logarithm of rice or corn production in province i and year t. R_{it}^{total} and R_{it}^{wet} measure the intensity of rainfall for the entire year and the wet season, respectively, which we define below.

To estimate the effect of rainfall on conflict, we use the same strategy but lag rainfall by one period, so our estimating equation becomes:

$$C_{it} = \gamma_0 + \gamma_1 R_{it-1}^{total} + \gamma_2 R_{it-1}^{wet} + \alpha_i + \lambda_i t + \varepsilon_{it} \tag{2}$$

where C_{it} denotes the conflict outcome of interest, which is either the number of casualties or the number of violent incidents (defined as incidents with at least one casualty) in province i and year t. The focus is on lagged rainfall because our working hypothesis is that rainfall affects conflict though agricultural production. Under this hypothesis, any effect of rainfall should not be realized until after the next harvest and potentially even later, since storage and savings may delay the effect of a bad harvest on household welfare.

As explained in Section 2, we define the wet season as May through October, and the remaining months as the dry season. The rainfall index is calculated as the sum of monthly rainfall z-scores in the relevant period. Thus, $R_{it}^{total} = \sum_{m=1}^{12} \frac{r_{mit} - \bar{r}_{mi}}{\sigma_{mi}}$, where r_{mit} is the rainfall level in month m, province i and year t, and $\bar{r}_{mi}$ and σ_m are the mean and standard deviation of rainfall in month m and province i over the entire period of observation, 2001-2009 (correspondingly, $R_{it}^{wet} = \sum_{m=5}^{10} \frac{r_{mit} - \bar{r}_{mi}}{\sigma_{mi}}$). We follow standard practice by using these aggregate, as opposed to monthly, measures of rainfall (e.g. Deschenes and Greenstone 2007, Lobell et al. 2008, Schlenker and Roberts 2009, Schlenker and Lobell 2010). This aggregation allows us to capture seasonal variation in the effect of rainfall while reducing the influence of measurement error typically observed in monthly rainfall estimates.[5]

The coefficient of R_{it}^{total}, γ_1, is equal to the change in conflict from a one standard deviation increase in precipitation measured over the course of a dry-season month; the sum of the coefficients γ_1 and γ_2 is equal to the change in conflict from a one standard deviation increase in precipitation measured over the course of a wet-season month; and the coefficient of R_{it}^{wet}, γ_2, is the difference between these two effects. If rainfall is related to civil conflict through agricultural production, then the coefficients β_1 and γ_1 should have opposite signs; likewise, the coefficients β_2 and γ_2 should have opposite signs. Because rainfall and temperature are highly correlated in the Philippines, the regression coefficients can be thought of as capturing the effects of both of these weather phenomenon in combination.

To control for unobservables potentially correlated with rainfall, our estimating equations include province fixed effects (α_i) and province-specific linear time trends ($\lambda_i t$). Following the majority of previous studies in this literature, we do not include time fixed effects in our estimating equation (Miguel et al., 2004; Burke et al., 2009; Schlenker and Lobell, 2010; Hsiang et al., 2011). While time fixed effects would allow us to more flexibly control for changes in time-varying unobservable variables at the country level, they have two significant

[5]Precipitation is typically measured with substantial error in global gridded datasets and temporal aggregation reduces attenuation bias by cancelling out some fraction of the individual errors (Lobell, 2013).

disadvantages in this context (Fisher et al., 2012; Aufhammer et al., 2013). First, time fixed effects can severely exacerbate the problem of measurement error in the rainfall variable. Rainfall is always measured with error, especially when it is aggregated to large-scale gridded datasets like the one we use here. By controlling for the average rainfall in a given year, time fixed effects remove a substantial part of the actual variation in rainfall. This can severely increase the ratio of noise to signal and result in significant attenuation bias in regression estimates (Fisher et al., 2012). Second, time fixed effects can introduce bias in the presence of spillovers from trade, migration, or movements of insurgents across province boundaries (Dell et al., 2014). To avoid these issues, our regressions exclude time fixed effects and rely on the assumption that variations in rainfall are random across years and therefore uncorrelated with time-varying common shocks that affected the country as a whole. To account for possible correlation of error terms across space as well as time, we use the spatial autocorrelation robust standard errors described by Conley (2008).

5 Results

Table 1 provides summary statistics for rainfall (by season), agricultural production and conflict-related causalities and incidents. It is apparent from these statistics that rainfall exhibits strong seasonality. During the dry season, provinces in our sample received an average of 164 millimeters of rainfall per month. In contrast, during the wet season, these provinces received an average of 265 millimeters of rainfall per month, a difference of approximately 60 percent.

On average, provinces experienced 6.6 conflict-related incidents per year, resulting in 14.1 casualties. Approximately 45 percent of total casualties were suffered by government forces; 30 percent were suffered by insurgents, with civilians making up the remainder. Sixty-two percent of casualty-producing incidents were initiated by insurgents, and insurgent-initiated incidents accounted for 55 percent of total casualties. Government-initiated incidents accounted for 44 percent of total casualties.

Disaggregation by insurgent group shows that the largest share of incidents (60 percent) involved the New People's Army (NPA). Incidents involving the NPA accounted for 58 percent of total casualties. The Moro Islamic Liberation Front (MILF) was involved in 10 percent of reported violent incidents, although these incidents accounted for 18 percent of casualties. Lawless Elements (LE) were responsible for 22 percent of incidents and 20 percent of total casualties. Finally, the Abu Sayyaf Group (ASG) was involved in less than 1 percent of violent incidents, accounting for less than 2 percent of casualties.[6]

5.1 Rainfall and agricultural production

Table 2 provides estimates of the relationship between rainfall and agricultural production. In columns (1) and (3), the estimated coefficient of R_{it}^{total} is small and statistically insignificant at conventional levels, suggesting that total rainfall received over the course of the year has little effect on agricultural production.

However, when R_{it}^{wet} is included on the right-hand side of the estimation equation, the expected seasonal pattern emerges, at least with regard to the rice harvest. Specifically, a one standard deviation increase in rainfall received during a dry-season month is associated with an increase in rice production of 0.5 percent. In contrast, a one standard deviation increase in rainfall received during a wet-season month is associated with a decrease in rice production of 0.9 percent. These estimates are statistically significant at the 1 percent and 5 percent levels, respectively; the difference between the estimates is significant at the 1

[6]These percentages do not add up to 100 because information on which group was involved is missing for approximately 4 percent of the incidents in our data.

percent level.

A slightly different seasonal pattern emerges for corn. The estimate of β_1 is positive when R_{it}^{wet} is included on the right-hand side of the estimation equation, but not statistically significant, while a one standard deviation increase in rainfall received during a wet-season month is associated with a decrease in corn production of 1.9 percent. This latter estimate is significant at the 5 percent level, and the difference between the wet- and dry-season estimates is significant at the 1 percent level.[7]

The results in Table 2 are generally consistent with what we know about the physiology of rice versus corn (Rathore et al., n.d.; Zaidi et al., 2004; Nishiuchi et al., 2012). Rice is a wetland plant and, as a consequence, more tolerant to waterlogging. Corn is better adapted to drier conditions, but more susceptible to flooding and submersion in water.

5.2 Rainfall and civil conflict

In this section, we explore the relationship between rainfall and conflict intensity. If this relationship exhibits seasonality, but with a lag and in the opposite direction as was found for agricultural production, this would be evidence against the infrastructure explanation.

We report estimates of equation (2) in Table 3. The estimated coefficients of R_{it}^{total} are negative, but insignificant, in columns (1) and (3). When R_{it}^{wet} is included on the right-hand side of the estimation equation, the estimates of γ_1 become larger (in absolute magnitude) and more precise. A one standard deviation increase in rainfall received during a dry-season month is associated with 1.02 fewer conflict casualties and 0.43 fewer conflict-related incidents

[7]During the period under study, three major typhoons struck the Philippines (one in December of 2006, one in June of 2008, and one in September/October of 2009). Controlling for which provinces were affected has almost no impact on the estimates presented in Tables 2 and 3.

the following year. These estimates are statistically significant at the 1 percent level. In contrast, a one standard deviation increase in rainfall received during a wet-season month is associated with 0.42 additional conflict-related incidents. The estimated relationship between wet-season rainfall and casualties is also positive, but insignificant.

In Table 4 we report estimates of a modified version of equation (2) that includes measures of rainfall from the current year, R_{it}^{total} and R_{it}^{wet}. Consistent with the infrastructure hypothesis, estimates of the relationship between wet-season rainfall in year t and conflict are negative. However, they are not statistically significant at conventional levels. Importantly, the estimated effects of lagged rainfall on conflict reported in Table 4 are similar to those reported in Table 3 both in terms of magnitude and precision.

Next, we allow the effect of rainfall on conflict to differ according to a measure of land use at the province level, $\frac{HectaresUnderCultivation_i}{TotalHectares_i}$, where the number of hectares under cultivation comes from the CountryStat database (published by the Philippine Bureau of Agricultural Statistics) and the total area of province i comes from the 2000 Census of the Philippines. Specifically, we estimate equation (2) separately for provinces with $\frac{HectaresUnderCultivation_i}{TotalHectares_i}$ greater than the median observed in our data, and for provinces with $\frac{HectaresUnderCultivation_i}{TotalHectares_i}$ less than the median observed in our data. If agricultural production is the mechanism linking rainfall and conflict, then we would expect estimates of γ_1 and of $\gamma_1 + \gamma_2$ to be larger in provinces with a greater-than-median proportion of total area under cultivation.

The results of this exercise are reported in Table 5. The estimated effects of rainfall on conflict intensity are much larger in provinces with a greater-than-median proportion of total area devoted to the cultivation of rice as compared to provinces with a less-than-median proportion of total area devoted to the cultivation of rice. This pattern of results, however, is less pronounced when we divide the sample based on proportion of total area devoted to the cultivation of corn. One possible reason for this pattern is that, as noted in

Section 2, corn is a cash crop and mostly used for livestock feed. It is therefore plausible that a failed corn harvest has a smaller impact on the wellbeing of the poor than a failed rice crop and, as a consequence, a smaller effect on civil conflict .

5.3 Disaggregation by initiator and victim

In this section, we investigate the effect of rainfall on conflict intensity by casualty type. The estimates in Table 6 suggest that the relationship between lagged rainfall and conflict intensity is most pronounced for civilians, which is notable given that civilians suffered substantially fewer casualties than government forces and insurgents during the period under study. A one standard deviation increase in rainfall during a dry-season month is associated with 0.55 fewer civilian casualties and 0.26 fewer incidents with at least one civilian casualty in the following year. The wet season estimates for civilians have the opposite sign: a one standard deviation increase in rainfall during a wet-season month is associated with 0.98 additional civilian casualties and 0.45 additional incidents leading to at least one civilian casualty.

In comparison, the wet-season estimates for government forces are much smaller than the estimates for civilians and are not distinguishable from zero in a statistical sense. Likewise, the estimated effects of rainfall on insurgent casualties and incidents resulting in at least one insurgent casualty are small and insignificant. Rainfall received during the dry season does, however, appear to impact casualties suffered by government forces: a one standard deviation increase in rainfall during a dry-season month is associated with 0.54 fewer casualties suffered by government forces and 0.26 fewer incidents resulting in at least one government casualty.

The results reported in Table 6 are consistent with those of van den Eynde (2011). Using data from India, van den Eynde (2011) found evidence of negative rainfall shocks on conflict due largely to an increase in insurgent-on-civilian violence. The results reported in Table 6 are also consistent with the hypothesis that rainfall shocks in the dry season shift the balance of power between insurgents and government forces, measured by the relative number of casualties suffered by these two groups.

In Table 7, we report estimates of the effect of rainfall on conflict intensity by who (that is, which group) initiated the violence. The results provide further evidence that rainfall can shift the power balance between insurgents and government forces. Specifically, we find that the estimated effects of rainfall on violent incidents initiated by insurgents are similar in size to those reported in Table 3. In contrast, the estimated effects on government-initiated incidents is close to zero and not statistically significant. Taken together, the results reported in Tables 6 and 7 are consistent with the hypothesis that rainfall shocks that are detrimental to agricultural production increase insurgent strength, enabling insurgent groups to inflict casualties on government forces and civilians who do not comply with their demands.[8]

5.4 Disaggregation by insurgent group and region

The Philippine military categorizes incidents based upon which insurgent group was involved. According to the military, the three main active insurgent groups operating in the Philippines are the communist New People's Army (NPA), the Muslim-separatist Moro-Islamic Liberation Front (MILF), the Islamist Abu Sayyaf Group (ASG). In addition to these armed insurgent groups, the military also reports conflict episodes involving armed criminal groups, or so-called "Lawless Elements", as recorded in military field reports. Lawless Elements (LE) are composed of apolitical criminal organizations and groups led by renegade former insur-

[8] It has also been suggested that an increase in insurgent-on-civilian violence could be the result of decreased insurgent strength, which increases the need to use violence to control the population and punish informants (Kalyvas, 2006; Wood, 2010). However, this mechanism is not consistent with our finding that rainfall shocks are more strongly associated with government casualties as compared to insurgent casualties.

gent commanders. Detailed descriptions of these four groups can be found in Section 2. In this section, we estimate the effect of rainfall on conflict intensity by region and by which armed group was involved. Our definition of region is based on where the MILF operates. MILF (and ASG) operations are confined to the southwest of the island of Mindanao and the Sulu Sea, while the incidents involving the NPA and Lawless Elements are reported throughout the country.[9]

Results of this exercise are reported in Table 8. Columns (1)-(3) show that outside the provinces in which the MILF operates, rainfall shocks detrimental to agriculture are associated with a substantial increases the number of incidents involving the NPA or Lawless Elements. In regions with MILF/ASG activity, rainfall appears to have different effects depending on which insurgent group was involved. Rainfall shocks detrimental to agriculture are associated with an increase in incidents involving the ASG and LE. However, above-average rainfall in the wet season, which is typically harmful to the rice crop, is associated with fewer incidents involving the MILF.

There are several possible explanations for this latter result. First, the MILF recruits and garners popular support based on ethnic, tribal and family relationships, whereas the NPA and Lawless Elements target the rural poor for recruiting and logistical support. As a consequence, negative shocks to agricultural production may provide fewer recruiting opportunities for the MILF than for the NPA and Lawless Elements. Another possible explanation is that negative shocks to agricultural production increase the likelihood of factional splits within the MILF. Because the Philippine military classifies smaller armed groups led by renegade MILF commanders as LE, factional splits could result in an increase in incidents attributed to LE and a corresponding decrease in incidents attributed to the MILF. This explanation is consistent with theoretical and empirical results that suggest that poor eco-

[9] Out of the 17 administrative regions of the Philippines, only 5 recorded MILF activity during the period of observation. These 5 administrative regions are divided into a total of 18 provinces. There was no MILF or ASG activity in the other 12 administrative regions of the Philippines.

nomic conditions and low state capacity lead to increased factionalization among rebel groups (Bueno de Mesquita, 2008; Fjelde and Nilsson, 2012).[10] A related explanation is that rainfall shocks affect how military units attribute incidents to the four group categories, even if there is little change in actual insurgent activity. The leadership of NPA and MILF often publicly denounce violence in regions affected by humanitarian crises such as drought or flood. Regardless of their actual affiliation, groups committing violence in these regions may therefore be more likely to be labelled as Lawless Elements because their actions contradict the public statements of the NPA and MILF leadership.

5.5 Magnitude

To gain a better sense of the magnitude of the reduced-form estimates presented in Table 3, we instrument for rice and corn production using R_{it}^{total} and R_{it}^{wet}. The assumption that rice and corn production are the only channels through which R_{it-1}^{total} and R_{it-1}^{wet} affect conflict intensity is most almost certainly violated because rainfall affects the production of other crops. Therefore, an instrumental variables (IV) approach should produce upper-bound estimates of the relationship between agricultural production and conflict.[11] It is also possible that lagged rainfall has effects on conflict that are unrelated to agriculture, in which case the bias depends on the direction of these effects.

Table 9 presents IV estimates of the effect of rice and corn production on our conflict measures. These estimates suggests that an increase in rice production of 10 percent leads to 0.6 fewer conflict-related incidents and 1.5 fewer casualties the following year. On average, we observe 6.6 conflict-related incidents and 14.1 casualties per province-year, so the IV esti-

[10] Our results are also consistent with evidence that rebel factionalization is often accompanied by increased violence against the state and civilians (Cunningham, 2013).

[11] This logic is, of course, based on the assumption that the seasonal effects of rainfall have the same sign for other crops as they do for rice and corn.

mates correspond to an elasticity of conflict with respect to rice production of approximately -1.

The IV estimates of the effect of corn production on conflict are not statistically different from zero. This pattern of results confirms our previous observation that the estimates of the effect of rainfall on corn production by season do not closely correspond to estimates of the effect of rainfall on conflict by season. It is also consistent with estimates reported in Table 5 suggesting that rainfall fluctuations have smaller effects on conflict in corn-growing areas than in rice-growing areas.

We propose two explanations for why corn production might be essentially unrelated to our measures of conflict intensity. First, it is possible that the IV estimates in Table 9 are biased by a direct effect of rainfall on conflict that cancels out the effect operating through corn production. As shown in Table 2, heavy rains in the wet season have a negative impact on the corn harvest, but if heavy rains also destroy roads and bridges in corn-growing provinces (increasing the cost of travel), then the estimated effect of corn production on conflict will be biased towards zero. The second possibility is that the effect of corn production on conflict is genuinely smaller than the effect of rice. As noted in Section 2, corn is a cash crop and mostly used for livestock feed, while rice is the staple food crop. It is therefore plausible that a failed rice harvest has a substantially larger impact on the wellbeing of the poor than a failed corn crop and, as a consequence, leads to more widespread discontent with the government and more support for insurgent groups.

6 Conclusion

In the Philippines and other parts of Southeast Asia, above-average rainfall can be an unexpected boon for farmers or it can ruin crops, depending on when it occurs (Lansigan et al., 2000; Gerpacio et al., 2011; Roberts et al., 2009). During the dry season, rice (and to a lesser extent corn) is susceptible to drought and above-average rainfall typically leads to an increase in agricultural production. During the wet season, above-average rainfall can lead to flooding and/or waterlogging and, as a consequence, poor harvests.

Using detailed data on conflict-related incidents collected by the Philippine military for its own internal purposes, we exploit the seasonal variation in the relationship between rainfall and agricultural production to learn about the mechanism through which rainfall affects the intensity of civil conflict. Our results are consistent with the hypothesis that rainfall affects conflict, at least in part, through agricultural production.

Three pieces of evidence are most salient. First, we find that contemporaneous rainfall is essentially unrelated to conflict as measured by the number of incidents or casualties, but lagged rainfall appears to be a robust predictor of conflict intensity. Because the effect of rainfall on agricultural production is realized at harvest, we would expect there to be a lag between rainfall and conflict, which we would not expect if rainfall worked through infrastructure or if rainfall had a direct influence on the psychology of combatants. Second, the relationship between rainfall and conflict-related incidents also exhibits seasonality, but in the opposite direction as for agricultural production. That is, above-average rainfall received during the dry season is associated with fewer conflict-related incidents and causalities one year later, while above-average rainfall received during the wet season is associated with more conflict-related incidents and causalities. Third and finally, the effect of rainfall on conflict appears to be more pronounced in provinces with a greater-than-median proportion of total area devoted to the production of rice.

Taken together, these results lend strong support to the argument that the channel through which rainfall impacts civil conflict is agricultural production. An unusually rainy wet season could make it easier for rebel groups to recruit in rice-growing regions and, as a consequence, lead to an increase in conflict intensity. According to the infrastructure hypothesis, an unusually rainy wet season would lead to a decrease, not an increase, in conflict.

Although climate change is not expected to have a major impact on total rainfall in Philippines or other Southeast Asian countries (Christensen et al., 2007; Asian Development Bank, 2009; B. and S., 2009), it is expected to amplify the already pronounced seasonal variation in rainfall. Our findings suggest that this amplification will exacerbate ongoing civil conflict in the Philippines and perhaps spark new conflict in other Southeast Asian countries, especially those heavily dependent on rice for subsistence.

Understanding the mechanisms through which climate change affects conflict is crucial to informing policy responses to climate change (Burke et al., 2015). Even under the most optimistic scenarios, substantial climate change appears to be unavoidable (IPCC, 2014, p.189), and designing policies that can increase societal resilience against civil conflict in the face of a changing climate will become increasingly important (World Bank, 2012; Center for Naval Analyses, 2014; USAID, 2014). Our results suggest that policies aimed at reducing the effect of climate change on agricultural production could weaken the link between climate change and civil conflict.

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Table 1. Summary Statistics

	Mean	Standard Deviation
Rainfall in wet season (mm/month)	265.3	77.9
Rainfall in dry season (mm/month)	164.4	108.7
Rice production (1000 metric tonnes)	197.5	223.0
Corn production (1000 metric tonnes)	75.2	140.0
Casualties	14.1	22.7
Government casualties	6.4	10.6
Insurgent casualties	4.3	10.1
Civilian casualties	3.4	7.1
Casualties in government-initiated incidents	6.2	13.3
Casualties in insurgent-initiated incidents	7.8	12.3
Casualties in incidents with the NPA	8.2	12.3
Casualties in incidents with the MILF	2.5	16.4
Casualties in incidents with the ASG	0.3	2.6
Casualties in incidents with LE	2.8	7.8
Violent incidents	6.6	8.2
Incidents with at least one government casualty	3.5	4.8
Incidents with at least one insurgent casualty	2.0	3.0
Incidents with at least one civilian casualty	1.9	2.9
Government-initiated violent incidents	2.5	3.7
Insurgent-initiated violent incidents	4.1	5.5
Violent incidents involving the NPA	4.0	5.7
Violent incidents involving the MILF	0.7	3.7
Violent incidents involving the ASG	0.06	0.44
Violent incidents involving LE	1.5	3.5
No. of provinces	75	75
No. of observations	673	673

The unit of observation is the province-year.

Table 2. Rainfall and Agricultural Production in the Philippines

	Log. of Rice Production		Log. of Corn Production	
	(1)	(2)	(3)	(4)
Annual rainfall index	–0.000	0.005***	–0.005	0.004
	(0.002)	(0.001)	(0.005)	(0.005)
Wet season rainfall index		–0.014***		–0.023***
		(0.005)		(0.008)
No. of provinces				
No. of observations	673	673	673	673

All regressions include province fixed-effects and province-specific linear time trends. Standard errors are in parenthesis, adjusted for spatial and temporal autocorrelation following Conley (2008). ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels.

Table 3. Rainfall and Conflict in the Philippines

	Total Casualties		Violent Incidents	
	(1)	(2)	(3)	(4)
Lag of annual rainfall index	–0.44	–1.02***	–0.15	–0.43***
	(0.30)	(0.39)	(0.10)	(0.13)
Lag of wet season rainfall index		1.73		0.85***
		(1.19)		(0.30)
No. of provinces				
No. of observations	598	598	598	598

All regressions include province fixed-effects and province-specific linear time trends. Standard errors are in parenthesis, adjusted for spatial and temporal autocorrelation following Conley (2008). ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels.

Table 4. Rainfall and Conflict: Effect of Rainfall in Current Year

	Total Casualties		Violent Incidents	
	(1)	(2)	(3)	(4)
Lag of annual rainfall index	–0.43	–1.01**	–0.16	–0.44***
	(0.34)	(0.40)	(0.11)	(0.12)
Lag of wet season rainfall index		1.81		0.83***
		(1.25)		(0.31)
Annual rainfall index	0.10	0.37	–0.13	–0.09
	(0.50)	(0.81)	(0.15)	(0.26)
Wet season rainfall index		–0.42		–0.05
		(0.89)		(0.32)
No. of provinces				
No. of observations	598	598	598	598

All regressions include province fixed-effects and province-specific linear time trends. Standard errors are in parenthesis, adjusted for spatial and temporal autocorrelation following Conley (2008). ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels.

Table 5. Robustness Test: Importance of Agricultural Land Area

	Total Casualties				Violent Incidents			
	Rice Area		Corn Area		Rice Area		Corn Area	
	High	Low	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lag of annual rainfall index	–1.45**	–0.53	–1.15**	–0.73**	–0.59***	–0.25*	–0.44***	–0.41***
	(0.62)	(0.33)	(0.52)	(0.30)	(0.19)	(0.15)	(0.15)	(0.13)
Lag of wet season rainfall index	2.56	0.54	1.96	1.27*	1.13***	0.46	0.95**	0.64*
	(1.59)	(0.97)	(1.72)	(0.66)	(0.42)	(0.34)	(0.41)	(0.36)
No. of provinces								
No. of observations	303	295	302	296	303	295	302	296

All regressions include province fixed-effects and province-specific linear time trends. The variables and denote the mean fraction of the province's land area that is planted to rice and corn during the period of observation, 2001-2009. Standard errors are in parenthesis, adjusted for spatial and temporal autocorrelation following Conley (2008). ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels, respectively.

Table 6. Rainfall and Conflict: Who Suffers the Casualties?

	Number of Casualties by Group			Number of Violent Incidents by Group		
	Government	Insurgent	Civilian	Government	Insurgent	Civilian
	(1)	(2)	(3)	(4)	(5)	(6)
Lag of annual rainfall index	–0.54***	0.07	–0.55***	–0.26***	0.02	–0.26***
	(0.21)	(0.18)	(0.15)	(0.09)	(0.06)	(0.06)
Lag of wet season rainfall index	0.25	–0.06	1.53***	0.28	–0.01	0.71***
	(0.63)	(0.47)	(0.41)	(0.23)	(0.13)	(0.13)
No. of provinces						
No. of observations	598	598	598	598	598	598

All regressions include province fixed-effects and province-specific linear time trends. Standard errors are in parenthesis, adjusted for spatial and temporal autocorrelation following Conley (2008). ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels.

Table 7. Rainfall and Conflict in the Philippines: Who Initiates the Violence?

	Casualties initiated by:		Violent incidents initiated by:	
	Government	Insurgents	Government	Insurgents
	(1)	(2)	(3)	(4)
Lag of annual rainfall index	–0.08	–0.90***	–0.03	–0.38***
	(0.24)	(0.24)	(0.09)	(0.11)
Lag of wet season rainfall index	–0.02	1.67**	–0.02	0.84***
	(0.72)	(0.70)	(0.22)	(0.21)
No. of provinces				
No. of observations	598	598	598	598

All regressions include province fixed-effects and province-specific linear time trends. Standard errors are in parenthesis, adjusted for spatial and temporal autocorrelation following Conley (2008). ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels.

Table 8. Rainfall and Conflict in the Philippines: Effects by Region and Insurgent Group

	Dependent Variable: Number of Violent Incidents							
	non-MILF Regions			MILF Regions				
	Total	NPA	LE	Total	NPA	LE	MILF	ASG
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lag of annual rainfall index	–0.47***	–0.26	–0.18**	–0.30	–0.00	–0.37*	0.18	–0.03
	(0.11)	(0.16)	(0.08)	(0.22)	(0.13)	(0.19)	(0.14)	(0.03)
Lag of wet season rainfall index	0.92***	0.57**	0.27**	0.64	–0.04	1.48***	–1.13***	0.19*
	(0.22)	(0.28)	(0.13)	(0.68)	(0.23)	(0.46)	(0.30)	(0.10)
No. of provinces								
No. of observations	456	456	456	142	142	142	142	142

All regressions include province fixed-effects and province-specific linear time trends. Standard errors are in parenthesis, adjusted for spatial and temporal autocorrelation following Conley (2008). ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels. Columns (1)-(3) report results for regions without MILF activity, columns (4)-(8) report results for regions with MILF activity. The abbreviations NPA, MILF, LE and ASG refer to the four most common insurgent affiliations reported by the AFP: New People's Army (Communist Terrorist Movement), Moro-Islamic Liberation Front, Lawless Elements, and Abu-Sayyaf Group, respectively

Table 9. Magnitude of the Effect: IV Estimates

	Casualties (1)	Violent Incidents (2)
Lagged log. of rice production	–14.94**	–6.02***
	(7.29)	(2.16)
Lagged log. of corn production	1.44	0.23
	(1.21)	(0.33)
No. of provinces	75	75
No. of observations	598	598

Lagged rice production and lagged corn production are instrumented by lagged total rainfall index and lagged wet season rainfall index. All regressions include province fixed-effects and province-specific linear time trends. Standard errors are in parenthesis, clustered at the province level. ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels.