ECONOMIC SHOCKS AND CIVIL CONFLICT: THE CASE OF LARGE FLOODS

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REFERENCE: *Proceedings of the 2013 Georgia Water Resources Conference*, held April 10–11, 2013, at the University of Georgia

Abstract. We investigate the impact of large floods on civil conflict in a sample of 125 countries between 1985 and 2009, employing GDP growth as a potential transmission channel. We instrument for floods and control for potential spatial and temporal dependency of civil conflict. We find that floods increase the probability of conflict incidence through their effect on GDP growth.

1. Introduction

Natural hazards such as earthquakes, volcanic eruptions, tsunamis, hurricanes, floods, and droughts are common sources of economic shocks (IMF, 2012). They can cause substantial damages and become natural disasters with profound environmental, political, and social consequences (Nel and Righarts, 2008). Previous studies have found that natural disasters increase the risk of civil conflict in a country (Bergholt and Lujala, 2012; Drury and Olson, 1998; Ghimire and Ferreira, 2012; Keefer 2009; Nel and Righarts, 2008). However except Bergholt and Lujala (2012), previous studies do not investigate the potential channels through which natural disasters can cause civil conflict, offering little insights for policy formulation.

In this paper, we investigate the impact of large floods on civil conflict, using GDP growth as a potential transmission channel and treating the occurrence of floods as an endogenous variable. Except Ghimire and Ferreira (2012), all previous studies treat the natural disasters as exogenous phenomena. However, the very definition of what constitutes a natural disaster in those studies is based on damages, and the damages are likely to be correlated with the same socioeconomic and institutional variables that determine the propensity of civil conflict. Countries with higher income and better institutions are less vulnerable to natural disasters (Cavallo and Noy, 2010; Ferreira *et al.*, 2011; Kahn, 2005). Ferreira and Ghimire (2012) find that an increase in income and improvement in institutions are also associated with fewer floods. Further, the emergence of new conflict or continuation of existing conflict could weaken disasters risk reduction efforts.

Between 1985 and 2009 floods, accounted for 40 percent of all the natural disasters (CRED/OFDA, 2011).The IPCC (2001, 2007, 2012) predicts that climate change can lead to change in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events and can result in unprecedented extreme weather and climate events. Brakenridge (2011) documents floods that are becoming larger and more frequent over the last 25 years. These events, interacting with exposed and vulnerable human and natural systems, can lead to disasters with profound environmental, political, and social consequences (Nel and Righarts, 2008).

Civil conflict is one of the greatest tragedies in human civilization. It impacts negatively on economic development and political stability. It is estimated that civil conflicts have resulted deaths of 20 million people and caused 67 million people to become refugees (Doyle and Sambanis, 2003). In this regard, identifying the potential transmission channel is important to formulate policies to mitigate negative impacts of large, catastrophic floods on broad social outcomes.

2. Natural disasters, economic growth, and civil conflict

The economic effects of natural disasters vary widely depending on the country and the type of disaster. Countries with favorable socioeconomic characteristics and institutions appear to be less vulnerable to natural disasters (Cavallo and Noy, 2010; Ferreira and Ghimire, 2012; Ferreira *et al.*, 2011; Kahn, 2005; Noy, 2009). In some studies, natural disasters have been found to be a positive force for economic growth particularly in developed economies.[1] In addition, the arrival of resources for reconstruction may provide a short-run boost to the affected regions.

Disasters, however, tend to be disastrous in poor countries. For example, Haiti's economy has shrunk more than eight percent since the 2011 earthquake (Surowiecki, 2011). In Pakistan, the 2011 floods appear to have reduced GDP growth by about 2 percentage points in 2011 (Looney, 2012). A typical hurricane that strikes in the central American and Caribbean region causes a reduction in annual output growth of about one percentage point (Strobl, 2008).

Contrary to droughts, hurricanes, and earthquakes, some studies find a positive macroeconomic impact of floods in long run, arguably through increased agricultural production and productivity that spills over to the rest of the economy (Fomby *et al.*, 2011; Loyza. *et al.*, 2009). However, in the short run large floods, like other natural disasters hit the economy and result into a decline in GDP growth. As argued by Collier and Hoeffler (1998, 2004), a low income or economic growth decrease the opportunity costs of young men to engage in conflict. The lower economic opportunities can result into frustration and grievances, making it possible to recruit rebels at modest compensation levels.

[1] An argument often made for the limited macroeconomic impact of natural disasters in developed countries is that disasters may be speeding up a Schumpeterian "creative destruction" process: by destroying old infrastructures, such as factories, roads, airports, and bridges, the disasters allow new and more efficient infrastructures to be built, forcing the transition to a sleeker, more productive economy in the long run (Skidmore and Toya, 2002).

Some socioeconomic characteristics such as high population density, youth bulges, natural resource dependence, and ethnic tensions are thought to provide suitable environments to breed conflict. Democratic institutions can reduce the risk of civil unrests (DeNardo, 1985; Francisco, 1995; Hegre *et al.*, 2001). Other characteristics, such as rough terrain (Collier and Hoeffler, 2004), and unrest in neighboring countries (Alcock, 1972) can also create a suitable environment for rebels to engage in civil unrest.

Although grievances may not be suffice to explain civil unrest, the grievances and competition for resources, combined with lack of representative institutions, economic redistribution mechanisms, and poor state capacity to deter violence, are a more likely explanation for civil unrest in the aftermath of large, catastrophic disasters (Gleditsch *et al.*, 2007).

3. Data

We compiled data on civil conflict, large floods, and a set of socioeconomic, political, and geophysical country characteristics and temporal-spatial controls for a total of 125 countries between 1985 and 2009 that are listed in the UPPSALA/PRIO civil conflict dataset.

3.1 Civil conflict data

We use civil conflict data from the annually updated UPPSALA/PRIO civil conflict dataset from the Uppsala Conflict Data Program (UCDP) (Gleditsch *et al.*, 2002; Themnér and Wallensteen, 2012). It defines civil conflict as "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which one is the government of state, results in at least 25 battle-related deaths." The dataset is very selective, including only politically motivated violence. In addition, it has a relatively low inclusion criterion (25 battle-related deaths during a year). The dataset is event-based, recording conflict events for a given country in a year. We make it annual by aggregating multiple events within a country-year. We use two indicators for civil conflict:

Onset of civil conflict: coded one when a new conflict emerges, there has been a total change in the opposite side, or when a conflict that has been inactive for more than two calendar years and becomes active again, and zero otherwise. In total, our dataset includes 97 onsets out of 2576 observations (4%).

Incidence of civil conflict: coded one if there are any types of conflict (new or existing conflicts) in a country-year, and zero otherwise. We have a total of 491 incidences out of 2576 observations (19%).

3.2 Flood data

Flood data come from the Dartmouth Flood Observatory (DFO) (Brakenridge, 2011), a publicly accessible global archive of large flood events, housed at the University of Colorado (http://floodobservatory.colorado.edu/). For a flood event to be considered 'large' and recorded in the dataset, it has to fulfill at least one of the following criteria: significant damage to structures, or agriculture, long reported intervals (decades) since the last similar event, and/or fatalities (Brakenridge, 2011).

The DFO records the flood data on the basis of country-event. We converted them to country-year observations by adding the number of flood events, and physical impacts of all flood events (magnitude) within a year for a given country. We code flood frequency zero if there are no floods reported in a country-year. Otherwise, we set it equal to sum of reported events in a country-year.

In addition to the number of floods, the DFO reports magnitude of each flood event as log (duration × severity × affected area). We code magnitude as zero if no floods were reported for a country-year. Otherwise, we compute total magnitude as the sum of the reported events' magnitude in a country-year.

Since we measure GDP growth in an annual basis, we need to adjust for the timing of flooding; a flood that hits economy in January will have a bigger impact on GDP in the same year than a flood that hits in December (Bergholt and Lujala, 2012; Noy, 2009). We adjust for this taking into account the onset month (*OM*):

$$Flood = \frac{(13 - OM)}{12} \qquad (1)$$

If a country has experienced several flood events during a year, the individual values are aggregated. The frequency of floods in our sample ranges from zero to 19 with nearly half flood event between 1985 and 2009 per country-year (standard deviation = 1.3). The magnitude ranges from zero to 161, with an average 3 per country-year (standard deviation = 8.3) (Table 1).

3.3 Other controls

We use GDP growth as the potential transmission channel between floods and civil conflict. In addition, per previous literature, we control for a range of socioeconomic, institutional, and geophysical country characteristics. We use per capita income to account for the opportunity cost of rebels to engage in civil conflict (Hegre and Sambanis, 2006). Other socioeconomic controls are population density, youth population, oil rents, infant mortality as a proxy for economic inequality, and ethnic tensions. Data for population density and infant mortality come from WDI (2010), youth population from WDI (2010) and United Nations (2010), oil rents from the World Bank (2010), and ethnic tensions from PRS (2011).

To control for political institutions, we use polity2 and polity2 square from the Polity2 regime indicators prepared by Marshall and Jaggers (2011), with the variables ranging from +10 (strongly democratic) to -10 (strongly autocratic). We control for regime instability as per Fearon and Laitin (2003) by creating a instability dummy with value one if there are three or more change in polity2 regime indicator over the last 3 years.

Because of the panel nature of UPPSALA/PRIO civil conflict data, we control for temporal dependency in the onsets equation. We construct a 'brevity of peace' variable as per Hegre *et al.* (2001), Toset *et al.* (2000), Nel and Righarts (2008), and Urdal (2006). We control for spatial dependency with a 'conflict in neighboring country' variable, that equals one if there is conflict in a neighboring country-year and zero otherwise.

Table 1: Descriptive statistics (country=125, observation=2576)

Variable	Mean	Std. dev.	Min	Max
Flood frequency	0.545	1.392	0	19
Flood magnitude	2.930	8.371	0	161.089
Onset	0.035	0.186	0	1
Incidence	0.181	0.385	0	1
GDP growth (%)	3.719	5.603	-51.030	106.279
GDP/capita	10969.88	12510.76	140.019	77108.22
Infant mortality	41.584	37.134	2.1	167.2
Youth population (%)	18.046	2.974	0.0481	26.105
Population density	148.373	537.276	1.312	7125.143
Oil rents	0.172	0.377	0	1
Ethnic tensions	3.939	1.428	0	6
Instability	0.111	0.314	0	1
Polity2	3.267	6.921	-10	10
Country area	992031	2185520	670	1.64E+07
Terrain ruggedness	0.626	0.410	0.004	2.197
Brevity of peace	0.236	0.391	0	1
Conflict in neigh. country	0.484	0.499	0	1
Coastal proximity	40.639	36.544	0	100
Variation in precipitation	61.002	50.009	0.862	391.151

We control for geophysical characteristics, such as terrain ruggedness and country area as addition covariates. Terrain ruggedness data comes from from Nunn and Puga (2010) and country area data from WDI (2010).

We instrument for floods using precipitation data (monthly variation in precipitation in mm) collected from TCCCR (2011); and coastal proximity (percentage of country's land area within 100 km of ice-free coast) from Nunn and Puja (2012). Summary statistics of all the variables are provided in Table 1. The table shows that there are much variations in indicators for conflict and floods across countries.

4. Estimation strategy

We assume that floods are a negative shock to GDP growth, and that shock contributes to worsen socioeconomic conditions increasing the risk of civil conflict. Not only floods, but also GDP growth is likely to be endogenous. We correct for endogeneity of floods and GDP growth in our model using a three step estimation procedure. In the first stage, we estimate the reduced form equation for floods ($Flood_{it}$), in the second stage we estimate the reduced form equation for GDP growth ($GDPG_{it}$), and finally we estimate the structural equation for conflict risk ($Conflict_{it}$). The system of equations can be summarized as:

$$Flood_{it} = f(X_{it-1}, Z) \tag{2}$$

$$GDPG_{it} = g(Flood_{it-1}, X_{it-1}) \tag{3}$$

$$Conflict_{it} = h(GDPG_{it}, X_{it-1}) \tag{4}$$

where *Flood* is an indicator for large floods (flood frequency, or magnitude adjusted by timing of flooding as in equation 1); ***X*** is a vector of controls that includes socioeconomic indicators – infant mortality rate, GDP per capita, youth population, population density, oil-rents (=1), ethnic tensions; political institutions – polity2, polity2 square, and instability (=1); geophysical characteristics – country area and terrain ruggedness; spatial-temporal controls – conflict in neighboring countries (=1), and brevity of peace; ***Z*** is a vector of instruments for floods that includes precipitation (monthly variation in precipitation) and costal proximity; *GDPG* is GDP growth; and *Conflict* is an indicator of civil conflict (either onset, or incidence).

The instruments used for floods are relevant as shown in the reduced form equations for floods (Table 2). We believe that they satisfy the exclusion restriction; precipitation and coastal proximity affect GDP growth through floods. We regressed GDP growth on monthly variation in precipitation with and without controls and found that precipitation was not a statistically significant determinant of either GDP growth, or conflict risk (onset and incidence). Further, coastal proximity does not directly affect either GDP growth, or civil conflict.

Civil conflict does not always follow immediately after the occurrence of natural disasters (De Boer and Sanders, 2004; De Boer and Sanders, 2005; Drury and Olson, 1998). We lagged the flood variables (frequency and magnitude) one period to accommodate the potential lagged effects. We also analyzed the robustness of the results to using alternative indicators for flood occurrence - magnitude of floods. In all the specifications, all explanatory variables are lagged one period to mitigate potential endogeneity bias. All the regressions include year dummies to control for year specific effects.

Econometric methods

We follow a three-step estimation procedure to estimate the model. In the first step we estimate equation (2) and then equation (3), both using a random effects model, and then we estimate two versions of equation (4) (one for conflict onset and another one for incidence) using a random effects logit model.

Instead of random effects, we could have used fixed effects to estimate the onset and incidence model, but Hausman tests favored it random effects (p=0.8729). Further, the use of fixed effects in non-linear models is generally inconsistent when the length of the panel is fixed and appears to be biased in finite samples (Greene, 2004; Wooldridge, 2002). Moreover, the use of fixed effects in our study drops a substantial number of observations from the sample; from 125 to 44 countries and from 2576 country-year pairs (observations) to only 959. It drops all the countries for which there is no variation in the dependent variable (e.g. because they did not experience any civil conflict, or they experienced civil conflict during the whole sample period). In this case, this country's contribution to the log-likelihood is zero and as such it has no effect on the estimation (Beck and Katz, 2001).

5. Results

After estimating the reduced form equation for floods (Table 2), we estimated 2 different versions of equations 2 and 3 depending on the dependent variables - conflict onset and conflict incidence. We summarize their average marginal effects (AMEs) in the last four columns of Table 2.

5. 1 Floods, GDP growth, and onset of civil conflict

In the reduced form equation for GDP growth (col. 3), the coefficient of the flood variable is negative and significant at a 5 percent level, implying that floods are a negative shock to GDP growth, with one additional flood lowering GDP growth in the next period by about 2 percent. The variables population density, country area, terrain ruggedness, and conflict in neighboring countries are also statistically significant determinants of GDP growth.

Table 2: Flood, GDP growth, and civil conflict (AMEs) (1985-2009)

VARIABLES	Reduced form for floods	Conflict onset		Conflict incidence	
		GDP growth	Onset	GDP growth	Incidence
Floods		**-2.175****		**-2.313****	
		(0.993)		**(1.018)**	
GDP growth			**-0.012**		**-0.037***
			(0.012)		**(0.022)**
Ln(GDP/capita)	0.326***	-0.413	-0.016	-0.430	-0.020
	(0.084)	(0.478)	(0 .016)	(0.430)	(0.038)
Ln(infant mortality)	0.366***	-0.272	0.003	-0.230	0.046
	(0.106)	(0.602)	(0.015)	(0.528)	(0.055)
Youth population	-0.038**	0.131	0.000	0.117	0.013
	(0.015)	(0.111)	(0 .003)	(0.108)	(0.014)
Ln(pop. density)	0.346***	1.036**	0.014*	1.073***	0.096***
	(0.065)	(0.408)	(0.011)	(0 .413)	(0.029)
Oil rents	-0.378**	0.301	0.041*	0.279	0.084
	(0.119)	(0.683)	(0.029)	(0.616)	(0.059)
Ethnic tensions	-0.038	0.224	-0.001	0 .241	-0.020*
	(0.022)	(0.182)	(0.004)	(0.193)	(0.011)
Instability	0.208**	0.221	-0.009	0.230	0.014
	(0.063)	(0.574)	(0.009)	(0.590)	(0.017)
Polity2	0.010	0.039	0.000	0.047	-0.000
	(0.007)	0.053	(0.000)	(0.054)	(0.001)
Ln(country area)	0.546***	0.921**	0.007	0.974*	0.057***
	(0.053)	(0.463)	(0.006)	(0.497)	(0.021)
Terrain ruggedness	-0.074	-0.716*	-0.004	-0.736*	0.050
	(0.169)	(0.435)	(0.013)	(0.443)	(0.048)
Conflict in neigh.	-0.063	0.848**	0.024*	0.857***	0.037
	(0.057)	(0.359)	(0.019)	(0.323)	(0.030)
Brevity of peace	0.107	-0.114	-0.012		
	(0.084)	(0.499)	(0.016)		
Ln(precipitation)	0.147***				
	(0.058)				
Costal proximity	0.005**				
	(0.002)				
Observations	2,576	2,576	2,576	2,576	2,576
Number of id	125	125	125	125	125

Note: Random effects model for reduced form equations and random effects logit model for structural equations. Bootstrapped Standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1

In the conflict onsets equation (col. 4), GDP growth has a negative coefficient, indicating that it decreases the probability of conflict onset, but the result is weak statistically (the coefficient is not statistically significant at the conventional levels). In contrast, population density, oil rents, and conflict in neighboring countries are all positive and statistically significant at 10 percent level or better. The marginal effects indicate that a one percent increase in population density increases the probability of conflict onset by about 1.5 percent. Countries with oil rents have a 4 percent greater probability of conflict onset than those without oil rents. Having civil unrest in neighboring countries positively and significantly increases the risk of conflict onset in adjacent countries by about 2.5 percent. The variables GDP per-capita, infant mortality, youth population, ethnic tensions, polity2, and country area all have the anticipated sign, but they are statistically insignificant.

5.2 Flood, GDP growth, and incidence of civil conflict

As shown in the reduced form equation for GDP growth (col. 5), the coefficient of the flood variable is negative and significant at a 5 percent level, implying that floods are a negative shock to GDP growth, with one additional flood lowering GDP growth by 2.3 percent for the average country in the next year. The variables population density, country area, terrain ruggedness, and conflict in neighboring countries are again statistically significant determinants of GDP growth.

Table 3: Flood, GDP growth, and civil conflict with alternative indicators for floods (AMEs) (1985-2009)

VARIABLES	Conflict onset		Conflict incidence	
	GDP growth	Onset	GDP growth	Incidence
Floods	**-0.309***		**-0.337***	
	(0.192)		**(0.187)**	
GDP growth		**-0.020**		**-0.045***
		(0.017)		**(0.031**
Ln(GDP/capita)	-0.766	-0.023	-0.806*	-0.029
	(0.473)	(0.020)	(0.457)	(0.047)
Ln(infant mortality)	-0.735	-0.003	-0.713	0.037
	(0.526)	(0.017)	(0.508)	(0.066)
Youth population	0.169*	0.002	0.154	0.015
	(0.098)	(0.003)	(0.098)	(0.014)
Ln(pop. density)	0.911**	0.015*	0.951**	0.097***
	(0.464)	(0.010)	(0.453)	(0.027)
Oil rents	0.829	0.049*	0.837	0.097
	(0.700)	(0.031)	(0.688)	(0.072)
Ethnic tensions	0.228	0 .000	0.250	-0.017
	(0.183)	(0.004)	(0.179)	(0.013)
Instability	0.146	-0.009	0.154	0.014
	(0.542)	(0.010)	(0.563)	(0.016)
Polity2	.0195	0.000	0.029	-0.000
	.0538	(0.000)	(0.055)	(0.001)
Ln(country area)	0.731	0 .006	0.786	0.055**
	(0.519)	(0 .006)	(0.513)	(0.020)
Terrain ruggedness	-0.704	-0.008	-0.736	0.044
	(0.474)	(0.011)	(0.470)	(0.047)
Conflict in neigh.	0.883**	0.0325*	0.891***	0.047
	(0.348)	(0.015)	(0.336)	(0.038)
Brevity of peace	-0.224	-0.015		
	(0.570)	(0.016)		
Observations	2,576	2,576	2,576	2,576
Number of id	125	125	125	125

Note: Random effects model for reduced form equations and random effects logit model for structural equations. Bootstrapped Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In the incidence equation (col. 6), the coefficient on GDP growth is negative, implying that a decline in GDP growth increases the probability of conflict incidence, and this effect is statistically significant. A one percent decrease in GDP growth increases the probability of incidence of civil conflict by 3.7 percent.

Results also show that a one percent increase in population density is associated with a 9.5 percent greater risk of conflict incidence. One unit improvement in ethnic tensions lowers the probability of conflict incidence by 2 percent. The variables GDP/capita, infant mortality, youth population, oil rents, instability, polity2, terrain ruggedness, and conflict in neighboring countries have the expected signs, but the results are weak statistically.

5.3 Robustness of results to alternative flood indicator

In Table 3, we use magnitude of floods as an alternative indicator of flood occurrence. As with flood frequency, we also adjusted for the timing of flood onset and instrumented for the flood magnitude variable using precipitation and coastal proximity. The results are similar to the baseline specifications; flood variable is statistically significant with a negative sign in the reduced form equations for GDP growth and GDP growth has a negative sign in both equations but is statistically significant only in the incidence equation. The controls are significant as per the baseline specifications.

6. Discussion and conclusion

Since one addition flood lowers GDP growth by about 2 percent and one percent reduction in GDP growth increases the probability of conflict incidence by about 4 percent, the combined effect, or the effect of one additional flood on conflict incidence is about a $2.3 \times 3.7 \approx 8.5$ percent larger probability of conflict incidence. With reference to our sample, the average country experienced approximately 0.54 flood event per year, which is associated with a 1.25 reduction in their GDP growth and results into $3.70 \times 1.25 \approx 4.63$ percent larger probability of conflict incidence. That is, the average country in our sample experienced a 4.63 percent larger risk of conflict incidence because of flooding.

The estimated impact of floods on GDP growth is large. However, case studies find that the estimated impacts could be much larger. For example, Pakistan experienced a 2 percentage point reduction in GDP growth after the 2010 massive inundations, which is equivalent to a 50 percent decline in GDP growth (Looney, 2012). Likewise, the 2011 October's deluge in Thailand lowered GDP growth by one percentage point, equivalent to 12 percent reduction in GDP growth in 2011 (Xinhua, 2011).

The slowdown in GDP growth could have huge socio, political impacts. Anecdotal evidence indicates that the Pakistani Taliban capitalized the frustration and grievance to strengthen their presence in the Northwest region, which was the most affected area by the flooding and also an epicenter of Pakistan's fight against al Qaeda and the Taliban (CBSNews, 2010; Righarts, 2010). However, there are few studies that analyze the impact of large, catastrophic disasters on broad social outcomes. Our work is a small effort to understand the potential impacts of large, catastrophic floods on GDP growth and on civil conflict.

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