Abstract: The relationship between natural resource exploitation and civil conflict has long been of interest to social scientists, and cross-country quantitative studies, applying various regression analysis methods, abound on the subject. Although the limited availability of data has historically prevented researchers from examining natural resource conflict at subnational scales, emerging techniques in the use of remote sensing and Geographic Information Science hold great promise for overcoming that challenge. The paper investigates the relationship between natural resource exploitation and civil conflict in the Republic of the Philippines. Georeferenced event data and remotely sensed land cover and nighttime light data were used to identify natural resource extraction projects, quantify environmental degradation, and construct subnational socioeconomic and conflict variables. A spatial probit regression model was estimated on a dataset comprising 1647 cities and municipalities in order to assess the strength of the relationship between mining activities and risk of conflict at the subnational scale, and to identify the contextual factors that shape that relationship. Results of the regression analysis indicate a strong relationship between the presence of mining activity in a municipality or city and the probability of conflict occurring, an effect that is strongest in areas affected by environmental degradation and land scarcity.
1. Introduction

On the morning of April 21, 2014 the municipal employees of the town of Gonzaga, Cagayan in the northeastern Philippines congregated in front of the town hall, as they do every week, for a flag-raising ceremony and address by their boss, Mayor Carlito Pentecostes, Jr. As the speech ended, several men dressed in the uniform of the Philippine National Police approached the mayor. Without warning, the men raised their weapons and shot the mayor repeatedly in the head and chest, killing him on the spot. In the chaos that followed, some fifty armed men stormed the municipal hall, overturning desks and tables, stealing computer equipment, and destroying others. The assailants fled in commandeered government vehicles to the jungle, leaving behind a smattering of printed leaflets—subsequently confiscated by police—that reportedly read “Punish the brains behind illegal mining.” Several days later, the New People’s Army (NPA), the armed wing of the Communist Party of the Philippines, claimed responsibility for the attack. Through a spokesman, the NPA claimed that Pentecostes had been sentenced to death in a “People’s Court” for, among other charges, his support of mining projects in Gonzaga, including several magnetite—known locally as ‘black sand’—mining operations by foreign companies, which the group claims damages the environment and local livelihoods (De Jesus 2014).

The culmination of a years-long conflict over mining in Gonzaga that escalated from litigation to increasingly confrontational protests and demonstrations, to vandalism and violence, the assassination is just one example of an increasing number of conflicts in the Philippines—and across the developing world—in which the exploitation of natural resources has played a defining role. Indeed, the relationship between natural resources and civil conflict has been the subject of scholarly and popular interest for several decades. The quantitative literature on the subject comprises a large number of cross-country regression analyses based on national-level statistics. Although past studies of this kind have presented some evidence of a relationship between the extraction of particular categories of resources—particularly oil—and the outbreak and duration of civil wars, the linkages remain a subject of debate.

This paper contributes to a very recent literature utilizing subnational conflict events data to examine the relationship between natural resource extraction and conflict at a higher resolution than has
heretofore been possible. It presents an empirical analysis of the relationship between mining and conflict in the Philippines. A spatial probit model was estimated relating the incidence of conflict events in 1628 municipalities and cities in the Philippines to the spatial distribution of mining operations. The results suggest that the number of mining concessions in a municipality does increase the likelihood of experiencing a conflict event, although this effect is limited to events involving the NPA rather than other armed groups in the Philippines. Mining concessions are found to be more strongly related to conflict events in municipalities with high levels of economic inequality calculated using a nighttime lights data. Environmental scarcity, measured in terms of the proportional loss of agricultural and forested land, was found to interact with the presence of mining activity to increase the risk of conflict.

The paper proceeds as follows. Section 2 provides background on natural resource extraction and civil conflict in the Philippines; Section 3 introduces the dataset and variables; Section 3 describes the statistical model; Section 4 presents the results of the analysis; and Section 5 concludes.

2. Background

(a) Natural Resource Extraction in the Philippines

The Philippines has a long history of natural resource extraction. As early as the third century A.D., Chinese histories make mention of the Philippine islands as a source of gold and, later, of copper and other metals. The country was a source of timber, metals, and cash crops during more than three centuries of colonialization and occupation by the Spanish, Americans, and Japanese. Trade liberalization of the 1990s, following the ouster of Ferdinand Marcos during the People’s Power revolution of 1986, ushered in a new era of resource exploitation involving foreign corporations, including especially American, Australian, and, increasingly, South Korean, Taiwanese, Chinese, and Japanese firms (Holden 2005).

The timber industry, which peaked in the early 1990s, has declined in importance as the country has become almost entirely deforested; today, following a country-wide mining ban instituted in 2011, the Philippines is a net importer of timber and the industry account for less than half a percent of GDP (World Bank 2016). The mining industry, however, has continued to flourish, encouraged by incentives
introduced by the Mining Act of 1995. These included a four-year income tax holiday; exemptions for
capital equipment imports from tariffs and taxes; a provision permitting income tax deductions to be
taken by mining companies for operating losses; favorable changes to depreciation calculations for tax
purposes; exemptions for mining operations for value-added taxes; and a guarantee of the repatriation of
profits and freedom from expropriation (United State Geological Survey 1995).

The Mining Act institutionalized two legal arrangements for extraction of mineral resources in
the Philippines—the Mineral Production Sharing Agreement (MPSA) and the Financial Technical
Assistance Agreement (FTAA). MPSAs and FTAAAs are agreements made between mining companies
and the Philippine government, represented in the former case by the Department of Environment and
Natural Resources and in the latter by the President of the Philippines, that can remain in effect for up to
twenty five years after approval. The major difference between the two is that, whereas MPSAs,
consistent with previous mining regulations, require that no more than 40 percent of a subject mineral
project can be owned by a foreign corporation, FTAAAs allow up to 100 percent ownership of a project by
a foreign entity (Holden 2005). In the years following the passage of the Act, mining activity in the
Philippines increased dramatically. Over twenty years, between 1995 and 2014, the value of economic
rents from mineral extraction in the Philippines increased from approximately 0.51 percent of GDP to
1.923 percent (World Bank 2016).

As is the case in many developing countries, the mining sector in the Philippines is fraught with
allegations of abuse, corruption, and environmental impacts. Particularly troubling are claims of
government targeting of anti-mining activists. Holden (2012, 2014) presents a picture of coordinated
repression of anti-mining activists organized at the highest levels of government and involving the
assassination of more than 1,330 people between 2001 and 2012, often by “motorcycle-riding men
wearing ski masks” (72). The reality is probably a great deal messier. Although the Philippine
government certainly does intervene in conflicts in mining issues by, for instance, authorizing the use of
the PNP or, in some instances, the military, to arrest protestors, conflicts between opponents and
supporters of mining are often highly localized affairs.
In Gonzaga, for instance, the conflict over mining began during the administration of Rosendo Abad, Pentecostes’ immediate predecessor and a staunch opponent of mining. Several high-ranking municipal employees were among those who were arrested during a 2008 protest against a proposed gravel quarry at the Wangag River. Widely seen as a referendum on the mining issue, the 2010 mayoral race between Abad and Pentecostes was, like many local elections in the Philippines, marred by claims of rampant vote-buying, intimidation, and violence. Although Pentecostes ultimately won the election handily, his election remained controversial among many residents, some of who brought legal challenges to his authority. During his administration, black sand mining operations were developed at several locations along the coast of the municipality, while the mayor and some members of his administration were accused of harassing anti-mining activists and threatening them with lawsuits and violence up until the time that he was killed by the NPA (E.A. Bucaneg, 2012, personal communication).

(b) Civil conflict in the Philippines

There is long tradition of revolutionary and separatist civil conflict in the Philippines, dating back at least to various struggles against the Spanish during more than three hundred years of colonization, as well as against American and Japanese occupation in the twentieth century. At present, the Philippine government is engaged in conflict against two broad insurgencies—the NPA, which is active throughout the country and a number of related, though often conflicting, organizations advocating the succession of regions of the southern island of Mindanao and the Sulu archipelago, the traditional homeland of the Muslim Moro minority, including the Moro Islamic Liberation Front (MILF) and Abu Sayyaf, among others. The latter, hereafter referred to collectively as the Moro insurgency, is heir to a conflict that dates back centuries; among the hundreds of distinct linguistic-ethnic groups of Philippines, it was the Moros who most successfully maintained independence, resisting conversion to Catholicism under the Spanish and fighting a protracted war of resistance against the Americans in the early twentieth century (Quimpo 2013).

The NPA presents itself as the heir to Communist guerilla resistance against the Japanese occupation during World War II. Following independence, the Hukbong Bayan Laban sa mga Hapones
(the People’s Army against the Japanese), evolved into an anti-government movement popularly known as the Hukbalahap or Huk rebellion. By the mid-1950s, the Huks had been largely defeated by the administration of Ramon Magsaysay, though a number of groups remained intact as organized criminal organizations involved in the extortion of gambling, prostitution, and other illegal and legal businesses (Holden 2007).

The Huks had maintained connections with the Partido Komunista ng Pilipinas (the Communist Party of the Philippines or CPP) since World War II. Jose Maria Sison reorganized the CPP in 1968, on the 75th birthday of Mao Zedong, under Maoist principles, breaking from the Marxist-Leninist tradition that had previously governed it. As Holden (2007) describes “what distinguishes Maoism from communism’s earlier variants is its reliance upon the peasantry, instead of the urban proletariat as the agent of change…Maoism is based upon a doctrine of “protracted people’s war” waged from the countryside, where revolution begins, subsequently expanding with a takeover of cities, and ultimately engulfing the entire country” (73). On March 29, 1969, some 72 former Huk fighters under the command of Bernabe Buscayno formed the NPA as the armed wing the CPP. The NPA grew rapidly during the 1970s, recruiting among a peasantry that was increasingly dissatisfied with the regime of Ferdinand Marcos. As the conflict intensified in the 1980s, Marcos declared martial law to deal with the insurgency (Quimpo 2013).

Since Marcos’ ouster in the 1986, the NPA has waned in strength and its current status as a political organization is a matter of some debate. One major change in its operation in recent years has been an increasing emphasis in its propaganda on natural resource extraction, specifically mining. Whereas the NPA and its predecessors had formerly railed in their propaganda materials against the injustices of the hacienda system, today’s NPA frequently cites mining activity as exemplifying the violence and greed of the international capitalist order. The NPA newsletter Ang Bayan, for instance, claims that “Mining operations cause incomprehensible destruction: they trample on the nation’s sovereignty. They cause widespread land grabbing. They plunder the nation’s natural resources and destroy the environment. They poison our waters, crops, fishing grounds, pasture lands, and other natural
sources of livelihoods” (qtd. in Holdren 2014, 76). The explicit role of mining and other forms of natural resources as a motivating factor for the NPA and Moro insurgencies is explored in the following section.

(c) Linking natural resources and civil conflict in the Philippines

The NPA and Moro insurgencies have been repeatedly cited by numerous authors as examples of their (often conflicting) theories of natural resource conflict. Indeed, the NPA (and, to a lesser, extent the Moro insurgency in Mindanao) has become a sort of theoretical Leatherman tool—a useful example of any theory to which it has been applied. In one the earliest application of econometric analysis to the study of civil conflict at the subnational scale, Mitchell (1969) emphasizes the strategic role of environmental features such as mountains, swamps, and forests as bases of operation for the Hukbalahap insurrection, the immediate precursor to the NPA. Myers (1989) uses the expanding support among the Philippine peasantry for the NPA in the 1980s as evidence for his Neo-Malthusian theory of conflict whereby absolute scarcity of natural resources and ecological services, driven by population growth, drove “impoverished throngs” into the arms of the militants.

Homer-Dixon’s (1990) model of ecological marginalization invokes the concept of relative deprivation to explain the development of grievances among of the Philippine peasantry, particularly in the uplands, leading subsequently to rising public support among this population for the insurgency. Kahl (2006), by contrast, attributes the increasing military and political success of the NPA to declining state capacity to ensure rule of law and provide basic services to marginalized communities, a situation which he attributes, in part, to increasing scarcity of agricultural land, forests, and other renewable resources and ecological services. Le Billon (2001, 2004, 2005), citing the group’s use of ‘taxation’ on resource extraction companies, including timber and mining operations, emphasizes the role of natural resources as a financing mechanism for militant groups.

Holden (2013, 2014) has conducted probably the most focused studies of the relationship between NPA conflict and mining in the Philippines. Noting the group’s vocal denunciation of mining in general and mining involving foreign corporations in particular as evidence of a grievance mechanism, he writes that “the opposition of the NPA to mining is an example of how, under conditions of accumulation by
dispossession, struggles over whether or not mining should occur at all have overshadowed the issue of how socially to divide the wealth created by mining” (61).

Yet, the sincerity of the NPA’s principled opposition to mining is somewhat belied by the group’s financial dependence on the industry. The NPA has historically levied such revolutionary taxes on all manner of businesses, ranging from transportation companies, to hotels, to illegal gambling and prostitution rings. Yet, among potential targets, mining operations are particularly vulnerable. Holden & Jacobson (2007) write that “It can take several years, and hundreds of millions of dollars, for a mining company to find, develop, and begin to mine a major mineral deposit. Once a mining project is developed it cannot be relocated and a mining company has a substantial incentive to pay funds to armed groups in exchange for being allowed to operate” (477). And pay they do, to the tune of millions of dollars per year. The International Crisis Group has estimated that the mining industry in northeastern Mindanao pays between 340,000 and 450,000 dollar per year (Holden 2014). It has been alleged that Canadian partner in the King-King Copper-Gold Project in Compostela Valley in Mindanao paid more than 1.7 million dollars over three years to various groups, including not only the NPA, but also Abu Sayyaf, and the MILF (Snell 2004).

Despite this windfall, the NPA appears to be rather divided internally with regard to the practice of extorting mining companies. “On January 7, 2011, the CPP declared that it will not levy revolutionary taxes upon mining companies because they “are beyond the pale of the revolutionary taxation being undertaken by the democratic organs of people’s governance.” Instead of collecting revolutionary taxes from them, the NPA would rather just see them “booted out” of the country. However, only two days later, on 9 January, 2011, Jorge “Ka Oris” Madlos, the NDFP Mindanao spokesperson, admitted that the NPA cannot drive them away, “they better pay taxes” (78).

The apparent paradox of the NPA’s vocal opposition to mining and its economic dependence on the industry can perhaps be best understood by considering the constraints facing insurgent groups in the Philippines, of which two are of primary importance. The first is financial—armed groups must raise funds to purchase weapons, vehicles, and food and supplies for fighters. The second constraint involves
the level of support among the populace for the group’s activities. In order to remain active, a group must needs develop a message that resonates with the population of the territory in which it operates; this is essential not only to ensure a continuing supply of recruits, but also to ensure that locals provide support in the form of material support as well as withhold information about their activities from the national government and its allies. In some circumstances, a group may become powerful enough within a territory that it can rely on force to ensure the cooperation of the local population (Kalyvas 2000). Until and unless it can reach this stage of control, however, the group must continue to align its messaging and activities with the grievances of the population with whom it interacts.

With regard to both sets of constraints, the NPA differs notably from the Moro insurgency. Whereas the latter receives financial support from external actors—namely international Islamic extremist groups—the support received by the NPA from international groups has diminished, leaving the NPA increasingly reliant on its extortion activities to fund its operations. The Moro groups also exert more complete political control over the areas in which they operate relative to the NPA. In those areas, the Moro groups also can rely upon a shared ethnic heritage with the general population of Mindanao that distinguishes them and the local population from the Philippines more generally. By contrast, the NPA is active throughout the country and is made up of members of every cultural group. Their appeal is strictly ideological, rather than cultural, and depends on the group’s ability to continuously align with the concerns of local people.

For the NPA, the controversy surrounding mining—and in particular mining by foreign corporations—provides an important means for addressing both sets of constraints. Mines are a ready source of extortion money. By attacking mines and individuals involved in mining activity, the NPA sends a message to local people that they are protecting their interests. By responding to threats against mining operations with increased militarization of mine sites and the targeting of anti-mining activities, the Philippine government validates the NPA’s message and strengthens its case in the eyes of local people.
The NPA’s longevity can be partially explained by its ability to remain politically relevant. Although its core ideology has remained generally constant with respect to the hatred for foreign occupiers, the shifting focus in its propaganda from rejection of the hacienda system to mining mirrors the evolving concerns of Filipinos. In the case of Gonzaga, there is strong evidence of a convergence between the grievances of activists and statements made by the NPA. Particularly striking is the emphasis on the part of both activists and rebels concerning the involvement of wealthy foreigners in mining activity. A post on the activist Facebook page “Save the Wangag River,” for instance, calls upon local leaders to “huway naman po sana natin hayaan na sirain ng mga dayuhan an gating kapaligiran [please do not allows the foreigners to destroy our environment].” Another, by a resident of Gonzaga on the website of the organization Coastal Care reads, “all of us feel so helpless and so sad knowing that the FOREIGN MINERS within our own residential communities prevail upon us, poor Filipino residents of our own titled lands.” Echoing this sentiment, the leaflets left behind by the NPA assassins of Mayor Pentecostes and subsequently confiscated by the police, reportedly read, “Hustisya para iti kaaduan, dusaen dagiti utek ti dayuhan a minas itit Cagayan [Justice for all. Punish the brains of illegal mining by foreigners in Cagayan]” (Lagacas & Catindig 2014; Dean 2014).

While activists, and the larger community of Gonzaga, have been condemnatory of the assassination of Mayor Pentecostes, some have made statements suggestive of a resigned and tacit approval. An April 26, 2014 post on the Facebook page “Cyber-Perling”, an anonymous page in support of the anti-mining activist and former mayoral candidate Esperlita ‘Perling’ Garcia, for instance, reads, “Nakakalunkot kailangan pang makiaalam ang mga NPA para lang masagip ang Sierra Madre laban sa mapanirang kasakiman at kurap a habang walang magawa ang ating pamahalaan para mapatigil at maipatupad ang pangangalaga sa Cagayan laban sa black sand mining [It is very sad that the NPA has to rescue the Sierra Madre from destructive greed and corruption while our government is helpless to protect Cagayan by stopping black sand mining].”

From the perspective of the NPA, when considering the contours of the constraints it faces, not all mine sites are equally important targets. Even if the NPA were a homogenous organization and one for
whom the existence of mining at all were seen as undesirable, some mine sites would present more important targets politically. Because the NPA’s ideology emphasizes the unequal distribution of the costs and benefits of development, local economic inequality represents one of the most important contextual factors to be investigated. The NPA is unlikely, it is proposed, to target mining areas where the wealth related to mining have been equally shared.

A similar line of reasoning suggests that the NPA should prefer to target mining operations in regions that face environmental scarcity, a condition that can be caused or exacerbated by mining activity. It is those areas that the grievances of the local population are most likely to aligned against mining and that the practice of the NPA to exert violence upon mining operations are most likely to find acceptance. This is not the case of “impoverished throngs” as per Homer-Dixon rushing into the arms of the insurgency, but rather an example of carefully considered political decision-making on the part of both the insurgency and the citizenry.

(d) Hypotheses

Based on the discussion above, it is anticipated that conflict events—and in particular events involving the NPA—will be more likely to occur three specific hypotheses have been defined, as follows:

**Hypothesis 1:** Municipalities with proposed or active mine sites will be more likely to experience a conflict event.

**Hypothesis 2:** Among municipalities with proposed or active mine sites, those with higher levels of economic inequality will be more likely to experience a conflict event.

**Hypothesis 3:** Among municipalities with proposed or active mine sites, those with higher land levels of land scarcity will be more likely to experience a conflict event.

Each of these hypotheses is tested in the analysis described in the following section. In addition, the analysis also distinguishes between events involving the NPA and other involving Moro or other groups, in order to assess the extent to which the characteristics of subnational groups in the Philippines affect the relationship between natural resource extraction and conflict.

3. Research Design and Data
(a) **Dependent variable**

The events data used in this analysis were obtained from the Global Terrorism Database, which tracks terrorist attacks globally based on media reports. In order to be included in the GTD, an incident must be intentional, must involve violence or the immediate threat of violence, and must be perpetrated by subnational actors. In addition, the incident must meet at least two of the three following conditions: (1) it must be aimed at attaining a political, economic, religious, or social goal; (2) there must be evidence of intent to coerce, intimidate, or convey some other message to an audience beyond the immediate victims; and (3) the action must be outside the context of legitimate warfare activities. Although the GTD excludes many events that occur during civil conflicts, including riots, violence perpetrated by the state against non-state actors or civilians, and pitched battles, the definition is broad enough to encompass most aspects of irregular warfare perpetrated by the NPA and Moro insurgencies, including, among other events, assassinations of political leaders; attacks on mines, logging operations, and other natural resource extraction sites; bombings of government buildings; and targeted and random killings of civilians based on ethnic or religious affiliation.

As a proxy for conflict intensity, the GTD appears to be most useful for low intensity and protracted insurgencies that involve organized nonstate actors. In the specific case of the NPA and Moro insurgencies, for example, the GTD provides a very reasonable snapshot of conflict activity. The modis operandi of the NPA, as well as of Abu Sayyaf, the MILF, and other Moro groups, all of which are considered to be terrorist organizations by the United States and Philippine governments, include assassinations of political leaders, attacks on businesses and government buildings, and, especially in the case of Abu Sayyaf, of kidnappings for random and random killings of civilians, activities that fit well within the GTD’s definition of terrorism.

The GTD contains records for a total of 2502 terrorist events in the Philippines during the period between 2004 and 2015. Some of these events were eliminated from the sample because a precise location was not identified in the GTD. Only events with a specificity of 1, 2, or 3 were included. The final dataset includes a total of 2435 events, the locations of which are shown in Figure 1 below. To
construct the final dependent variable, a binary variable was defined such that a municipality in which at least one conflict occurred between 2004 and 2015 was assigned a value of 1 and those that did not experience a conflict event were assigned a value of 0.

(b) Independent Variables

In order to test the hypotheses above, three independent variables of interest were generated using georeferenced and remotely sensed data. The first of these is the number of active mining sites located within each municipality. Static maps of mining tenements from the Philippines Mines and Geosciences Bureau were digitized to produce the map in Figure 1 below showing the locations of mining areas (FTAAs and MPSAs) in the Philippines.

It is important to note that the actual area affected by mining is certainly different than and most likely a great deal less than the area encompassed by concessions. Concessions data, however, while widely used proxy of natural resource extraction, are not precise measurements of such. Some concessions are never fully developed, while small scale illegal and quasi-legal mining operations are not captured by official concessions data. In order to identify areas that have experienced recent environmental degradation as a result of mining, a change-detection algorithm was applied to remotely sensed imagery of the Philippines. The algorithm follows the decision-tree procedure described in Hansen et al. (2013); rather than identifying the loss of forest cover however it identifies land cover change from either forests or agriculture to bare ground. The presence of mining activity in the pixels identified by the algorithm was confirmed by review of high resolution satellite imagery from GoogleEarth. The imagery used in the analysis comprise the circa 2000 and circa 2013 composite images from the Global Forest Change project and therefore, the areas represent areas that were actively mined between 2000 and 2013.

Remote sensing methods were also used to develop a measure of environmental scarcity. For each municipality/city, the average percent change in the normalized difference vegetation index (NDVI) between 2000 and 2010 was calculated. NDVI is based on the fact that actively photosynthesizing vegetation reflects infrared light and absorbs red light and is calculated as the ratio of the difference
between the intensity of reflected near infrared light and the intensity of visible red light to the sum of the intensities of near infrared and visible red light.

Because it is highly sensitive to changes in the photosynthetic productivity of vegetation, NDVI is widely used to identify land use changes. A significant increase in mean NDVI over the period may represent reforestation, but is more likely to indicate the conversion of forest to high intensity agriculture, which is more photosynthetically productive than natural ecosystems. A decline in NDVI may represent the loss of agricultural area due to soil degradation, deforestation, or urbanization. For the purposes of this study, NDVI is used as a general measure of change.

Figure 1. Natural resource extraction, environmental scarcity, and conflict in the Philippines

To test the extent to which economic inequality increases the risk of conflict associated with mining requires a subnational measure of economic inequality. Traditional measures of inequality, such as the widely-used Gini coefficient, have historically been based on data collected during household surveys, which are often prohibitively expensive and difficult to conduct, particularly in developing countries and even more so in areas affected by civil conflict. This study utilizes an original method for estimating subnational inequality based on remotely sensed nighttime lights and land cover data.
As described in Keola & Andersson (2015) and elsewhere, nighttime lights can be used as a proxy measurement for economic activity. Nighttime lights data collected by the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument were obtained from the National Oceanic and Atmospheric Administration (NOAA). As shown in in Figure 2 below, nighttime lights are most intense in urban areas, especially in the Metro Manila area. Aggregated to provincial level, the average intensity of the nighttime lights is highly correlated \((r=0.92)\) with the estimate of regional gross domestic product published by the Philippine government.

To generate a measure of per capita income from the VIIRS nighttime lights data, an independent measure of population is required. A population variable was constructed from the LandScan population data product (see Figure 2). Because LandScan relies on interpretation of land cover—i.e. the presence of buildings and infrastructure) to estimate population, the resulting variable is independent of the nighttime lights data; dividing the latter by the former yields a measure of per capita income at a high spatial resolution.

The per capita variable was aggregated to the scale of the barangay, the tertiary administrative division in the Philippines. In terms of its spatial extent and population, the barangay is the equivalent to the village or, in urban areas, neighborhood. A municipality-level measure of economic inequality was then defined using Theil’s (1967) mean logarithmic deviation method, such that:

\[
T_i = \sum_{j=1}^{j} p_j \log \left( \frac{\mu_j}{y_i} \right)
\]

Where \(y_j\) is economic productivity per capita in barangay \(j\) of municipality \(i\), \(p\) is the population share of barangay \(j\), and \(\mu\) is average economic productivity per capita across all barangays of municipality \(i\). It is important to note that the resulting metric is a measure of spatial inequality—the variance in per capita income among barangays, rather than between individuals. The extent to which this measure of spatial inequality can be considered a proxy measure of individual inequality cannot be precisely validated in the absence of survey data.
The relationship between mining, inequality, and scarcity was examined using a cross-sectional spatial probit model, as described below. The scarcity and inequality variables were interacted with the mining variables in order to test for a joint effect.

(c) Control Variables

In addition to the three independent variables of interest measuring, respectively, the presences of mining sites, spatial economic inequality, and environmental scarcity, several municipal-level control variables were included in the statistical models described below. These are total population, measured using the LandScan dataset; economic productivity per capita, estimated by dividing the nighttime lights data by the LandScan population estimate; and population density, in people per square kilometer. In addition, a regional indicator variable is included to control for whether a municipality is located within the Autonomous Region of Muslim Mindanao, the geographical area over which the Moro insurgency is explicitly being waged.

(d) Model Specification

It has been observed that conflict tend to be contagious. Although the spatial distribution of conflict at the subnational level is far from systematic—indeed, the apparent unpredictability of conflict
events at the subnational level is a subject of intense academic interest—there is little doubt that
countries, districts, and communities located near conflict areas are often at greater risk for experiencing
conflict themselves. To account for potential autocorrelation in the dependent conflict variable, a spatial
autoregressive probit model was estimated, such that:

\[ y_i^* = \beta_0 + \beta_1 x_i + \rho W y_i + \mu \]

Where \( y^* \) represents a latent dependent variable that is expressed as a binary outcome (i.e. either
a conflict occurred during the time period examined or it did not); \( x \) is the vector of explanatory variables
and includes the independent variables and interaction terms that are of primary interest, \( \mu \) is the residual
error, and \( \beta \) and \( \rho \) are fitted constants. The term \( W \) represents the spatial weights matrix. This is a block
diagonal matrix that defining the spatial structure of the model. In this study, a standard spatial weights
matrix was used. If each row in the matrix represents an observation \( i \) and each column represents an
observation \( j \), then each entry is defined as 1 divided by the number of observations neighboring
observation \( i \), if observation \( j \) is among the neighbors of observation \( i \), and zero otherwise. By design, the
entries for each row sum to one. For example, if a municipality or city has 5 neighbors, the entry for each
neighbor is 0.2 and the entries for all non-neighboring observations is 0.

A number of methods have been proposed for estimating spatial regression for dichotomous
choice dependent variables. A simulated maximum likelihood estimation method was developed by
Beron & Vijverberg (2004) from McMillen (1992) is often referred to as recursive-importance-sampling
as it relies on a Monte Carlo simulation of truncated multivariate normal distributions. The advantage of
this method, according to Elhorst et al. (2013), is that is provides a feasible and efficient algorithm to
approximate an N-dimensional truncated normal density function that is required to maximum to the log-
likelihood function. Historically, this method was computationally intensive; however, recent advances
have utilized sparse matrix algorithms to speed up computation time. Perhaps the most commonly used
method for estimating the spatial probit is Bayesian Markov Chain Monte Carlo (MCMC), owing perhaps
to the availability of algorithms for its implementation in a number of statistical software packages. The
MCMC method avoids the use of multidimensional integration and the assumptions on which it relies.
For this study, the spatial probit model was estimated using the Bayesian MCMC described in Wilhelm & de Matos (2013) and implemented in the R package spatialprobit.

4. Analysis

(a) Mining and Conflict

Table 1 shows the results of the preliminary regressions, which do not include the joint effect variables. The number of mining concessions in each municipality was a statistically significant and positive predictor of the number of conflict events overall and of attacks perpetrated by the NPA in particular. Interestingly, however, the number of mines that resulted in environmental impact was not independently significant, suggesting that the NPA responds to the presence of mining activity, rather than the impact of that mining.

<table>
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<th>Conflict events</th>
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<th>All events</th>
<th>NPA events</th>
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<tr>
<td>Mines2</td>
<td>0.000</td>
<td>0.015</td>
<td>0.127</td>
<td>0.127</td>
<td>0.209</td>
<td>0.208</td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.020)</td>
<td>(0.091)</td>
<td>(0.091)</td>
<td>(0.144)</td>
<td>(0.135)</td>
</tr>
<tr>
<td>Theil</td>
<td>-0.031</td>
<td>-0.124</td>
<td>-0.127</td>
<td>-0.127</td>
<td>0.209</td>
<td>0.208</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.088)</td>
<td>(0.091)</td>
<td>(0.091)</td>
<td>(0.144)</td>
<td>(0.135)</td>
</tr>
<tr>
<td>NDVI</td>
<td>-0.011</td>
<td>-0.028</td>
<td>-0.030</td>
<td>-0.030</td>
<td>-0.186***</td>
<td>-0.137</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.017)</td>
<td>(0.020)</td>
<td>(0.020)</td>
<td>(0.066)</td>
<td>(0.095)</td>
</tr>
<tr>
<td>NDVI</td>
<td>-0.127**</td>
<td>0.115**</td>
<td>-0.225**</td>
<td>-0.225**</td>
<td>-0.184</td>
<td>-0.176</td>
</tr>
<tr>
<td></td>
<td>(0.055)</td>
<td>(0.054)</td>
<td>(0.062)</td>
<td>(0.062)</td>
<td>(0.114)</td>
<td>(0.127)</td>
</tr>
<tr>
<td>Lights</td>
<td>-0.127**</td>
<td>0.115**</td>
<td>-0.225**</td>
<td>-0.225**</td>
<td>-0.184</td>
<td>-0.176</td>
</tr>
<tr>
<td></td>
<td>(0.055)</td>
<td>(0.054)</td>
<td>(0.062)</td>
<td>(0.062)</td>
<td>(0.114)</td>
<td>(0.127)</td>
</tr>
<tr>
<td>Density</td>
<td>-0.038</td>
<td>-0.043</td>
<td>-0.828**</td>
<td>-0.828**</td>
<td>-0.552*</td>
<td>-0.619</td>
</tr>
<tr>
<td></td>
<td>(0.087)</td>
<td>(0.097)</td>
<td>(0.333)</td>
<td>(0.333)</td>
<td>(0.295)</td>
<td>(0.460)</td>
</tr>
<tr>
<td>Population</td>
<td>0.253***</td>
<td>0.251***</td>
<td>0.212***</td>
<td>0.212***</td>
<td>0.362***</td>
<td>0.355***</td>
</tr>
<tr>
<td></td>
<td>(0.033)</td>
<td>(0.032)</td>
<td>(0.039)</td>
<td>(0.039)</td>
<td>(0.063)</td>
<td>(0.077)</td>
</tr>
<tr>
<td>Moro</td>
<td>0.560***</td>
<td>0.549***</td>
<td>-0.608***</td>
<td>-0.608***</td>
<td>1.244***</td>
<td>1.193***</td>
</tr>
<tr>
<td></td>
<td>(0.125)</td>
<td>(0.130)</td>
<td>(0.188)</td>
<td>(0.188)</td>
<td>(0.175)</td>
<td>(0.175)</td>
</tr>
<tr>
<td>Spatial lag</td>
<td>0.279***</td>
<td>0.284***</td>
<td>0.358***</td>
<td>0.358***</td>
<td>-0.014</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>(0.043)</td>
<td>(0.047)</td>
<td>(0.052)</td>
<td>(0.052)</td>
<td>(0.067)</td>
<td>(0.123)</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.791***</td>
<td>-2.435***</td>
<td>-2.91***</td>
<td>-2.91***</td>
<td>-5.557***</td>
<td>-5.372***</td>
</tr>
<tr>
<td></td>
<td>(0.353)</td>
<td>(0.344)</td>
<td>(0.424)</td>
<td>(0.424)</td>
<td>(0.702)</td>
<td>(0.891)</td>
</tr>
</tbody>
</table>

Notes: * p<0.10  **p<0.05  ***p<0.001
Standard errors in parentheses
Among the covariates, both total population and total area increased the risk of experiencing a conflict event. Economic productivity per capita, based on the VIIRS nighttime lights data, was statistically significant and negative, suggesting that, controlling for population, wealthier areas are less likely to experience conflict.

(b) Mining, Inequality, and Conflict

Including the interaction terms between inequality and mining in the statistical models yields the results shown in Table 2. The product of the mining concessions variable and the Theil index is a statistically significant and positive for all conflict events and for events involving the NPA, though not for event involving Moro groups. This suggests that the presence of mining operations is more likely to cause conflict in municipalities with high spatial economic inequality.

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>All</th>
<th>All</th>
<th>NPA</th>
<th>NPA</th>
<th>Moro</th>
<th>Moro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mines1</td>
<td>-0.003 (0.032)</td>
<td></td>
<td>0.016 (0.033)</td>
<td></td>
<td>-0.038 (0.078)</td>
<td></td>
</tr>
<tr>
<td>Mines2</td>
<td></td>
<td>-0.027 (0.037)</td>
<td></td>
<td>-0.040 (0.045)</td>
<td></td>
<td>-0.609** (0.295)</td>
</tr>
<tr>
<td>Theil</td>
<td>-0.135 (0.084)</td>
<td>-0.043 (0.095)</td>
<td>-0.184* (0.015)</td>
<td>-0.145 (0.093)</td>
<td>0.224 (0.139)</td>
<td>0.126 (0.126)</td>
</tr>
<tr>
<td>NDVI</td>
<td>-0.009 (0.008)</td>
<td>-0.019 (0.008)</td>
<td>-0.028** (0.015)</td>
<td>-0.032** (0.017)</td>
<td>-0.071 (0.076)</td>
<td>-0.301* (0.174)</td>
</tr>
<tr>
<td>Mines1*Theil</td>
<td>0.132** (0.057)</td>
<td>0.133** (0.061)</td>
<td>0.116 (0.087)</td>
<td></td>
<td>0.020 (0.116)</td>
<td>0.433 (0.426)</td>
</tr>
<tr>
<td>Mines2*Theil</td>
<td></td>
<td>0.080 (0.079)</td>
<td></td>
<td></td>
<td></td>
<td>0.433 (0.426)</td>
</tr>
<tr>
<td>Lights</td>
<td>-0.138*** (0.055)</td>
<td>-0.120*** (0.053)</td>
<td>-0.249*** (0.067)</td>
<td>-0.216*** (0.065)</td>
<td>-0.215* (0.127)</td>
<td>-0.158 (0.128)</td>
</tr>
<tr>
<td>Density</td>
<td>-0.104* (0.061)</td>
<td>-0.098 (0.064)</td>
<td>-0.833*** (0.317)</td>
<td>-0.885*** (0.303)</td>
<td>-0.412 (0.491)</td>
<td>-0.675 (0.489)</td>
</tr>
<tr>
<td>Population</td>
<td>0.247*** (0.033)</td>
<td>0.253*** (0.033)</td>
<td>0.211*** (0.041)</td>
<td>0.214*** (0.040)</td>
<td>0.322*** (0.077)</td>
<td>0.376*** (0.085)</td>
</tr>
<tr>
<td>Moro</td>
<td>0.588*** (0.130)</td>
<td>0.562*** (0.129)</td>
<td>-0.587*** (0.182)</td>
<td>-0.591*** (0.200)</td>
<td>1.152*** (0.198)</td>
<td>1.240*** (0.197)</td>
</tr>
<tr>
<td>Spatial lag</td>
<td>0.286*** (0.045)</td>
<td>0.291*** (0.040)</td>
<td>0.361*** (0.049)</td>
<td>0.342*** (0.056)</td>
<td>0.158 (0.179)</td>
<td>0.012 (0.107)</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.704*** (0.351)</td>
<td>-2.77*** (0.350)</td>
<td>-2.478*** (0.445)</td>
<td>-2.513*** (0.434)</td>
<td>-4.898*** (0.961)</td>
<td>-5.569*** (0.939)</td>
</tr>
</tbody>
</table>
Table 3 shows the results pertaining to the joint impact of environmental scarcity and mining on conflict. The interaction term between the number of mining concessions and the rate of environmental change is not significant; however, the number of mining sites that resulted in observable environmental impacts and the rate of environmental change is significant. This suggests that environmentally impactful mining, while not independently predictive of conflict, may create the preconditions for conflict when it occurs in areas of high environmental scarcity.

**Table 3. Effect of Mining and Scarcity on Conflict Risk**

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>All</th>
<th>ALL</th>
<th>NPA</th>
<th>NPA</th>
<th>Moro</th>
<th>More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mines1</td>
<td>0.100*** (0.026)</td>
<td>0.128*** (0.025)</td>
<td>0.061* (0.035)</td>
<td>-0.009 (0.043)</td>
<td>-0.326 (0.231)</td>
<td></td>
</tr>
<tr>
<td>Mines2</td>
<td>0.037 (0.032)</td>
<td>-0.135 (0.088)</td>
<td>-0.117 (0.088)</td>
<td>0.194 (0.147)</td>
<td>0.204 (0.139)</td>
<td></td>
</tr>
<tr>
<td>Theil</td>
<td>-0.045 (0.080)</td>
<td>-0.032 (0.075)</td>
<td>-0.021* (0.013)</td>
<td>-0.023 (0.015)</td>
<td>-0.151** (0.068)</td>
<td></td>
</tr>
<tr>
<td>NDVI</td>
<td>-0.007 (0.007)</td>
<td>-0.010 (0.008)</td>
<td>-0.135 (0.088)</td>
<td>-0.117 (0.043)</td>
<td>-0.098** (0.038)</td>
<td></td>
</tr>
<tr>
<td>Mines1*NDVI</td>
<td>0.055*** (0.018)</td>
<td>0.081*** (0.024)</td>
<td>0.048* (0.026)</td>
<td>-0.127 (0.084)</td>
<td>-0.089 (0.111)</td>
<td></td>
</tr>
<tr>
<td>Mines2*NDVI</td>
<td>0.030 (0.020)</td>
<td>-0.233*** (0.063)</td>
<td>-0.220*** (0.070)</td>
<td>-0.168 (0.141)</td>
<td>-0.160 (0.135)</td>
<td></td>
</tr>
<tr>
<td>Lights</td>
<td>-0.114** (0.055)</td>
<td>-0.108** (0.053)</td>
<td>-0.878*** (0.260)</td>
<td>-0.707** (0.303)</td>
<td>-0.799 (0.579)</td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>-0.043 (0.099)</td>
<td>-0.032 (0.096)</td>
<td>-0.219*** (0.040)</td>
<td>0.205*** (0.041)</td>
<td>0.353*** (0.069)</td>
<td></td>
</tr>
<tr>
<td>Population)</td>
<td>0.254*** (0.034)</td>
<td>0.255*** (0.033)</td>
<td>0.219*** (0.040)</td>
<td>0.376*** (0.068)</td>
<td>0.353*** (0.069)</td>
<td></td>
</tr>
<tr>
<td>Moro</td>
<td>0.574*** (0.131)</td>
<td>0.555*** (0.127)</td>
<td>-0.608*** (0.190)</td>
<td>-0.602*** (0.196)</td>
<td>1.277*** (0.173)</td>
<td></td>
</tr>
<tr>
<td>Spatial lag</td>
<td>0.285*** (0.041)</td>
<td>0.286*** (0.045)</td>
<td>0.356*** (0.053)</td>
<td>0.364*** (0.056)</td>
<td>1.246*** (0.174)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-2.808*** (0.367)</td>
<td>-2.796*** (0.357)</td>
<td>-2.591*** (0.427)</td>
<td>-2.436*** (0.437)</td>
<td>-5.675*** (0.730)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: *p<0.10 **p<0.05 ***p<0.001
Standard errors in parentheses
A final point of interest is the difference in the significance of the explanatory variables in the models predicting events involving the NPA and those involving Moro groups. Compared to the NPA, events involving Moro groups do not appear to be dependent on most of the variables included in the models. Aside from the Moro indicator, only the population variable and the bare ground variable are significant. Events involving Moro groups also do not appear to be spatially correlated within the Moro region. A more limited analysis may be required in order observe local variations in Moro activity.

5. Conclusions

Kalyvas (2000) writes that “whereas conventional wars neatly divide space into two well defined and clearly demarcated spaces, irregular wars show up as messy patchworks; the more detailed the map, the messier it looks” (98). This observation is exemplified in the Philippines, where several of long-standing insurgencies wage guerilla campaigns against the national government. Among the variables that may explain the spatial distribution of conflict events in the Philippines is the distribution of natural resource extraction projects. This is especially true for events involving the NPA, for whom mining projects constitute both an important source of financing and a subject of messaging for gaining and maintaining recruits and the support of the general public.

The original methods described in this paper for assessing the relationship between subnational measures of economic inequality, natural resource extraction, and civil conflict lend some important insights into the dynamics of insurgency in the Philippines, particularly with regard to the motivations, opportunities, and constraints facing the NPA.

The results suggest that conflict involving the NPA is most likely in communities where the communities where the benefits of natural resource extraction are unequally shared and in those where environmental scarcity has been exacerbated by environmentally impactful mining activity. They also suggest that poverty can explain the incidence of conflict not only between but also within countries and that very local variation in income levels is an important predictor of conflict. Although local inequality economic inequality does not appear to directly increase the risk of conflict, the results suggest that inequality interacts with natural resource extraction to consistently increase the risk of conflict.
It is increasingly recognized that conflict, far from being matter of simple cost benefit analysis, is actually a complex function of poverty, resource distribution, horizontal and vertical inequalities, and historical legacies of oppression (see Le Billon 2013, Cederman et al. YEAR, OTHERS). Holden & Jacobson (2007), for instance, write that “The NPA use the rhetoric of ideology (communism) to galvanize their members, and the MILF use the rhetoric of theology (Islam) to galvanize their members, but in both cases, it is ultimately the poverty and social exclusion that cause the movements to come into existence” (493). Subnational research of the type presented in this paper bears great promise for identifying the specific social, economic, and environmental factors that cause or exacerbate conflict and the opportunities for mitigating it.
References


