Conflict, Minerals, and Value Chains

This paper examines the differential impacts of critical mineral mining projects relative to mineral processing projects in developing countries. Recent efforts by Indonesia and others to limit exports of raw mineral materials indicate that developing countries are increasingly looking to move up the critical mineral supply chain by developing higher value, processed commodities. Policymakers in the US and other developed countries have also begun to advocate for the development of processing capacity as a means of avoiding the resource curse and promoting more responsible investments in international mining. While existing research has examined the effect of mining projects on local employment and conflict levels, little is known about the impact of investments in the more downstream portions of mineral supply chains. This research fills an important gap by providing insight into potential differences between mining and processing projects, and the extent to which the latter provide a pathway to improving human security in developing countries.

Lit Review [Placeholder]

Some notes on the causal pathways through which mineral resources impact conflict, courtesy of Chat GPT:

1. Resource Competition: The presence of valuable mineral resources can lead to competition among individuals, groups, or even nations for control over those resources. This competition can escalate into conflicts, ranging from disputes over land rights to armed conflict over control of mines.
2. Economic Disparities: The extraction and trade of mineral resources can exacerbate economic disparities within local communities. While some individuals or groups may benefit financially from resource extraction through employment or business opportunities, others may feel marginalized or excluded from the economic benefits. This disparity can create tensions and conflicts within the community.
3. Environmental Degradation: Mineral extraction often involves significant environmental impacts, such as deforestation, water pollution, and habitat destruction. Local communities may oppose mining operations due to concerns about the loss of livelihoods, damage to ecosystems, and health risks associated with pollution. Environmental conflicts can arise between mining companies, local communities, and environmental advocacy groups.
4. Land Rights and Displacement: Mining activities may require large tracts of land, leading to conflicts over land rights and displacement of local communities. Indigenous peoples and marginalized groups, in particular, may face displacement from their traditional lands, leading to protests, resistance, and sometimes violent conflict.
5. Governance Issues: Weak governance, corruption, and lack of transparency in the management of mineral resources can contribute to conflicts. Inadequate regulation and enforcement of environmental and social standards, as well as disputes over revenue sharing and benefit distribution, can further fuel tensions and grievances within communities.
6. External Actors: The involvement of external actors, such as multinational corporations, foreign governments, and armed groups, in mineral extraction can complicate local dynamics and increase the risk of conflict. External actors may exploit local resources for their own benefit, exacerbating existing tensions and contributing to instability.

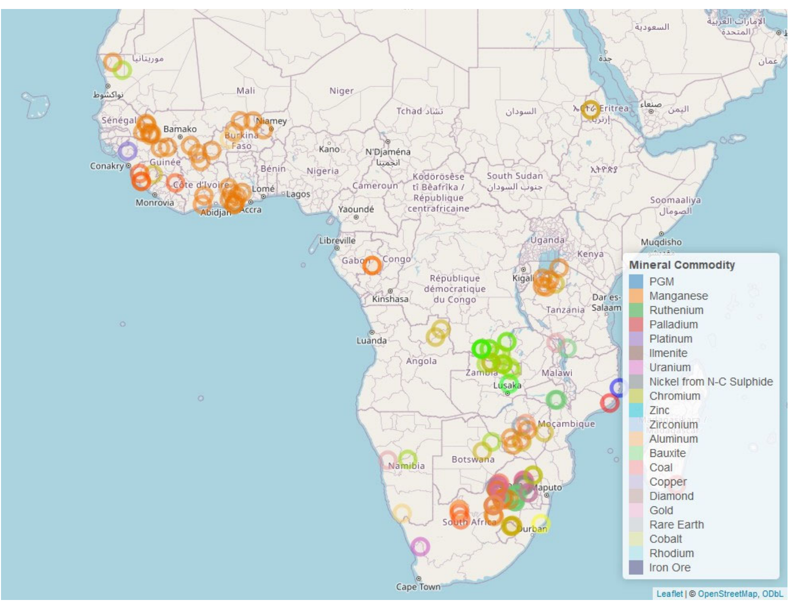
In terms of the impact of mining vs. processing projects, it is unclear how adding value would necessarily overcome these challenges. On one hand, higher value projects could require a larger and more technically trained workforce, which could result in more positive economic spillovers. Greater technical

Commented [EY1]: Feedback/ideas on causal pathways would be greatly appreciated complexity could also be associated with more sophisticated firms with the capacity to invest in local communities and infrastructure, beyond the bare minimum required for their operations. Costlier infrastructure and equipment for advanced processing could also increase firms' incentive to take steps to mitigate potential local conflict, for example, through CSR programs. Lastly, higher value projects could be associated with local institutions with the capacity to demand investment in value-addition versus extraction alone. On the other hand, for the types of large-scale mining projects included in the Africa Power Mining Projects Database (discussed below), it is unclear whether high processing projects would face fewer challenges with regards to environmental degradation or the displacement of local populations. Processing projects in general are known to be highly polluting due to high energy requirements and the chemicals required to break down or otherwise separate raw ores. Regardless of processing capacity, the owners of these types of projects are likely to have significant resources and local influence.

Data and Processing

I combine data from two sources to conduct this analysis. The first source is the **Africa Power Mining Projects Database** published by the World Bank, which includes georeferenced data on ongoing and forthcoming mining projects in Africa categorized by the type of mineral, ore grade, and size of the project. Notably, the Projects Database includes a variable for "extent of processing," indicating the degree to which mined materials at processed onsite. The database draws on basic mining data from various payment-based and publicly available information sources and consists of 455 projects in 28 Sub-Saharan African countries for which the project's ore reserve value is assessed at more than $250 million. The Projects Database was first published in 2014 and last updated in 2017.

Figure 1: Africa Power Mining Projects Database - Projects by mineral commodity

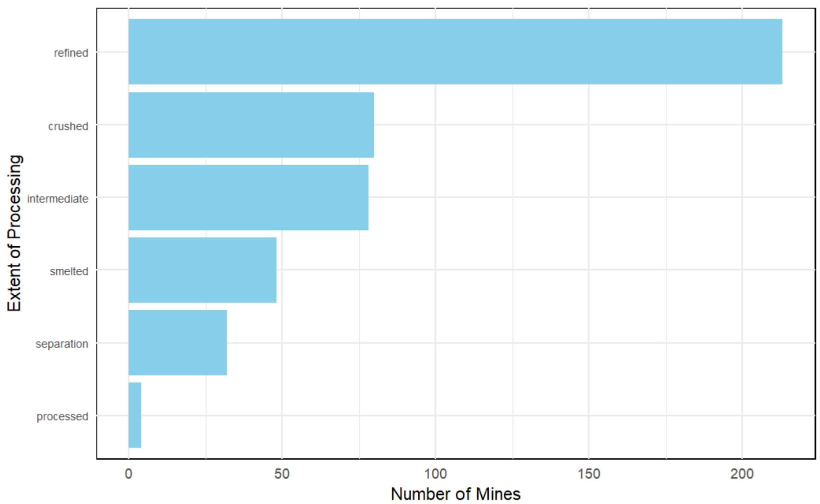


The Projects Database includes mineral projects across of range of project stages, from exploration and feasibility assessment to production. As only a small fraction of exploration initiatives yield mineral resources that are economically viable to extract, I limit my sample to mining projects that are actively in production, taking the first year of production as my treatment start time.

Commented [EY2]: I need help thinking through how I've constructed my counterfactual -- mining projects with low amounts of processing. I'm worried because these projects are also being "turned on" so their status is changing too

As mentioned above, the Projects Database includes a variable for "extent of processing." Figure 2 below shows the distribution of mines in the database across levels of processing. "Crushed," "intermediate" and "separation" tend to be associated with lower levels of processing, whereas "refined," "smelted" and "processed" indicate higher levels of processing and value addition.

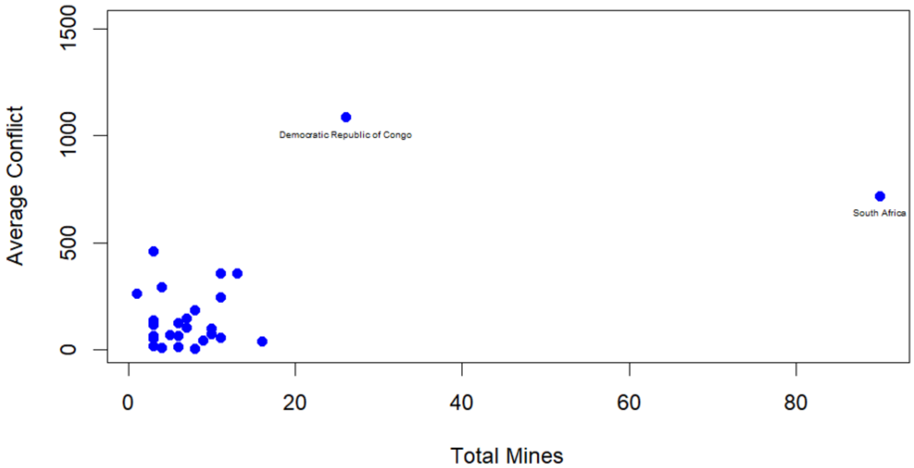
Figure 2: Number of mining projects by processing level



My second data source is the **Armed Conflict Location & Event Data Project (ACLED)**, which collects georeferenced data on the type, agents, location, date, and other characteristics of various conflict events, including political violence events, demonstration events, and other select non-violent, politically-relevant developments in every country and territory in the world. ACLED data is available from 1997 to the present.

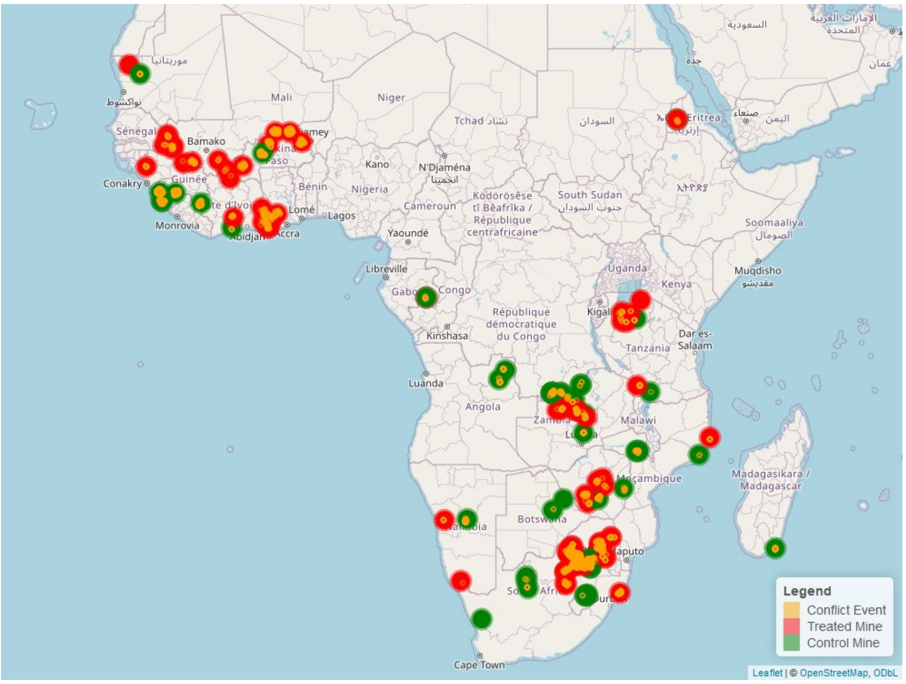
As seen in Figure 3 below, at the country level, there is variability both in the number of mining projects and level of conflict. The Democratic Republic of the Congo and South Africa in particular show high levels of both conflict and mining activity. The remaining countries are scattered closer to the origin, with fewer than 20 mining projects and 500 average annual conflict events.

Figure 3: Average annual conflict by number of mining projects by country



To conduct my analysis, I matched conflict events within 32km of mining projects. I chose this distance to account for the fact that for large mining projects, economic and other impacts are likely to be felt beyond the immidiate confines of the mining area, but also to take into consideration the weakneing effect of moving too far away from any given project. I used this matched dataset to construct a panel dataset of average annual conflict for treated (high processing) and untreated (low processing) mining projects within my sample from 1997-2023. As shown in the figure below, treated and untreated mines are distributed fairly randomly across Sub-Saharran Africa, with varying levels of local conflict depending the individual project.

Figure 4: Conflict events by mining project treatment status.



Methods

I used a difference-in-differences (DiD) approach to estimate the average effect of opening a high processing mining project relative to a low processing project on the number of conflict events in and around mining sites. Mining areas and the communities around them are likely to have underlying, unobserved characteristics that are associated with conflict, such as a history of competition among different ethnic groups. A DiD approach is helpful because it allows us to "purge out" time-invarying factors that may be correlated with both treatment status and conflict. In this way, the DiD approach gives us a better measure the causal effect of the treatment (on the treated group) than a simple pre-post comparison for treated mining areas. Failing to "difference out" these time-invarying factors for example, by simply comparing the rate of conflict in mining areas before and after the introduction of a high processing project, would likely lead to a biased estimate of the effect of the project on conflict.

I estimate the treatment effect using the following DiD model:

Commented [EY3]: Is this model still okay even if I'm technically using Callaway and Sant'Anna?

$$Y_{it}= \alpha_i + \lambda_t + \sum_{k=-K}^{-2} \beta_k Treat(k)_{it} + \sum_{l=0}^{L} \beta_l Treat(l)_{it} + \varepsilon_{it}$$

Where α_i is the unit or mine site fixed effect, λ_t is the time or year fixed effect, $Treat_{it}$ is a centered indicator for whether mine site i was treated in year t, β_k is the pre-treatment DiD estimate, and β_l is the time-period specific treatment effect in comparison to a reference period, in this case t=0, the production start year of a mining project. Additionally, I also conducted an event study analysis to test whether the treatment effect changes over time, for example, whether conflict increases or decreases at high processing mining areas relative to low processing mining areas as the projects mature.

There are known issues with using two-way fixed effects regressions when there are multiple periods / variation in treatment timing. I use the "did" package in R Studio, which implements the framework put forward by Callaway and Sant'Anna (2021) and corrects for these issues, to estimate treatment effects.

Commented [EY4]: I tried including controls for FDI flows, GDP per capita, and unemployment at the country-level using World Bank data but I wasn't able to run the regressions - I think because for some countries there is missing or incomplete data.

Results

I found that on average, high processing mineral projects resulted in a slightly higher level of conflict in comparison to low processing projects. Specifically, the weighted average of treatment effects across group-time estimates indicates that new, high processing projects increased the average annual number of conflict events by 4.8 conflicts, which is a substantively large effect accounting for 336% of the mean value of this outcome for the treatment group in the pre-intervention period (1.1 average annual conflicts). This estimate is statistically significant at conventional significance levels.

Figure 5 shows how the treatment effect evolves over time. The pre-period trend shows that there is no statistically significant difference between the treated and control mines. In other words, the parallel trends assumption required for DiD holds. Starting in the 3rd year after the start of production, trends in conflict appear to deviate between high and low processing projects, with high processing projects experiencing higher levels of conflict. Although the average effect the group-time estimates is statistically significant, the individual post-treatment estimates have a wide rage of uncertainty associated with them.

Commented [EY5]: Because my N for treated and control is small?

Figure 5: DiD estimates of the effect of high processing mining projects relative to low processing projects over time

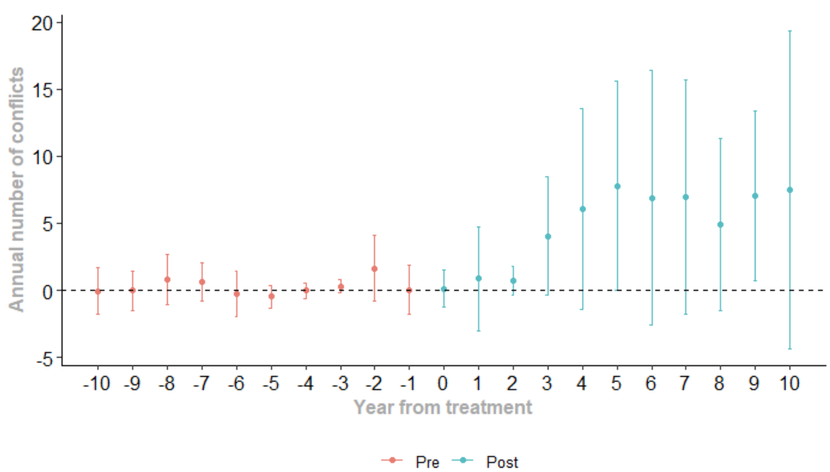


Table 1: Treated mine count for each treatment timing estimate

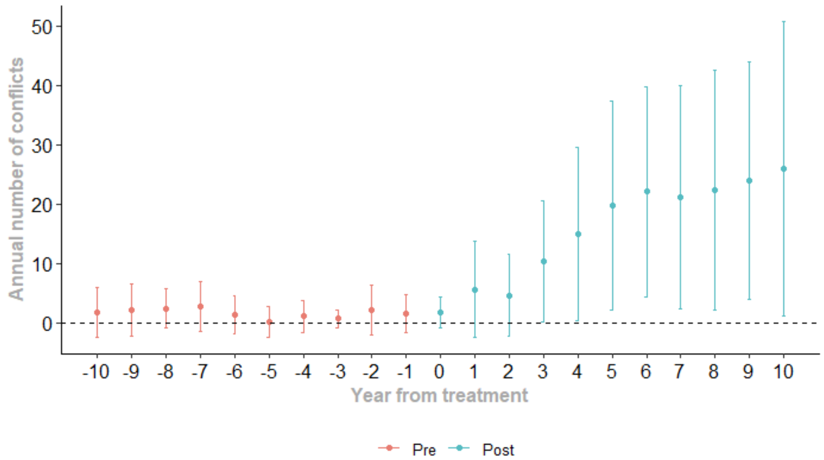
Time from treatment (in years)	Mine count (treated)
-10	47
-9	57
-8	65
-7	69
-6	72
-5	74
-4	77
-3	82
-2	87
-1	88
0	93
1	93
2	93
3	93
4	93
5	93
6	93
7	93
8	93
9	92
10	90
Total mines	*143*

Sensitivity Tests

I conducted a number of analyses to test whether these results are robust to changes in the underlying data and other data processing decisions. First, because of concerns related to the reliability of the ACLED data, I used an alternative data source for conflict that is generally considered to be more reliable. This alternate source – the Uppsala Conflict Data Program (UCDP – differs from ACLED in that it defines a conflict event more narrowly as "an incident where armed force was used by an organised actor against another organized actor, or against civilians, resulting in at least 1 direct death." Because I am interested in exploring the impact of mining on broader forms of conflict that may not involve death or injury, I chose to use the ACLED dataset as my primary source. The results using UCPD generally matched the results using ACLED.

Second, I changed the distance between mining projects and conflict events to see whether a smaller or larger radius around a project would change my results. The smaller distance (16km) resulted in much noisier estimates in the post-treatment period, while the larger distance (64km) more clearly demonstrated the increasing trend among high processing projects in the post-treatment period (Figure 6), perhaps because it was able to capture a wider degree of variability in conflict between treatment and control mines.

Figure 6: DiD estimates of the effect of high processing mining projects relative to low processing projects over time, 6 (64km radius)



Third, I was concerned about potential spillover effects between mining projects. To explore this issue, I generated a dummy variable for projects that were in close proximity to each other (specifically within the treatment radius) and excluded these mines to test whether spillovers were impacting my results. Again, my results remained relatively unchanged.

Fourth, I excluded South Africa, which from Figure 3 is a clear outlier both in terms of conflict and mining projects. The DiD estimates were not substantively changed by excluding this outlier.

Lastly, I explored changes to my outcome variable. I looked specifically at subsets of conflict events, such as peaceful demonstrations and violent protests, to test whether aggregating all conflict types was masking underlying patterns. Again, my initial results were robust to these additional tests.

Next Steps

My findings are surprising. Instead of being associated with lower conflict or even similar levels of conflict, high processing projects seem to be contributing to *higher* levels of conflict. My main concern is that I may be failing to account for some unobserved, time-varying source of heterogeneity between treated and control mines. The figure below in particular shows a notable uptick in the number of conflicts in and around high processing mining areas starting around 2012. Am I sufficiently controlling for potential sources of bias?

This relates to my intended next steps for this project. First, I would like to examine whether there are key mining areas where conflict in the post 2012 period is concentrated, and what the underlying sources of this conflict might be. Second, I would like to dig further into the ownership structure the firms in the Projects Database, as there is some literature that suggests that ownership may impact local unemployment. More importantly, I also want to supplement this analysis with a qualitative analysis of the ACLED data for a subset of the mines within my scope. Specifically, ACLED includes narrative descriptions of the individual conflict events. I'd like to further explore these in order to better understand the causal mechanism(s) at play.

Figure 7: Total conflict events over time by treatment status