Evaluating Due Diligence Programs for Conflict Minerals:

Evaluating Due Diligence Programs for Conflict Minerals: A Matched Analysis of 3T Mines in Eastern DRC

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IPIS PRG SFR Ulula

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International Peace Information Service (IPIS) conducted the study's field research in the provinces of South Kivu and Maniema in eastern Congo, including the data collection at mining sites and households. IPIS also contributed to the village and mine site sample selection, design and development of the survey instruments, and data analysis.

Sub-Saharan Field Research and Consulting Services (SFR) led the enumerator training and supported the design of the survey instruments.

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Cover image: Washed cassiterite by Timo Makori.

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Executive Summary

The 2010 Dodd-Frank Act requires that US-listed companies sourcing so-called "conflict minerals" from Africa's Great Lakes region conduct due diligence. (The EU now imposes similar requirements.) Due diligence programs (DDP), following guidelines from the OECD, provide ongoing monitoring of mineral production and processing to ensure that suppliers respect human rights and do not contribute to conflict. A decade later, we still have limited evidence about whether DDP impacts economic and security conditions.

To help fill this gap, we evaluate the impacts of DDP on mining communities in the eastern Democratic Republic of Congo (DRC). Combining statistical matching with new data from over one hundred 3T (tin, tantalum, and tungsten) mines and one thousand households, we report several findings:

1. DDP areas see less interference by the Armed Forces of the Democratic Republic of Congo (FARDC). Households in DDP areas report 27% less FARDC presence and taxation relative to households in non-DDP areas.

2. DDP areas see a heightened presence of government regulators. Households in DDP areas report over 58% more tax collection and service provision by government regulators; they do not, however, report feeling more secure than households in areas without DDP.

3. Mines in DDP areas do not have significantly lower rates of child labor. Some child labor is reported at roughly one third of mines in DDP areas, a rate that is not statistically distinguishable from mines in non-DDP areas.

4. DDP areas show hopeful, if statistically inconclusive, evidence of greater economic well-being than non-DDP areas.

How one regards these impacts depends on the benchmark for success. We detect meaningful progress toward several goals in DDP areas; yet, we also find that DDP does not eliminate all of the harms associated with 3T mining in the eastern DRC. We uncover reasons to applaud these efforts, but also room for improvement, particularly with respect to labor practices and miners' livelihoods.

Our results rely on the analysis of original survey data collected from 104 mine sites and 1,054 households in nearby villages in South Kivu and Maniema at the end of 2019. We employ a matching technique that compares mining areas with and without DDP that have similar geographies, histories of conflict, and development trajectories. This statistical approach helps us isolate differences that can be attributed to DDP.

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Acronyms and Abbreviations

ACLED	Armed Conflict Location and Event Data
ASM	Artisanal and Small-scale Mining
BGR	Federal Institute for Geosciences and Natural Resources
CEM	Coarsened Exact Matching
CNPSC	National Coalition of the People for the Sovereignty of Congo
DDP	Due Diligence Programming
DRC	Democratic Republic of Congo
FARDC	Armed Forces of the Democratic Republic of Congo
FDLR	Democratic Forces for the Liberation of Rwanda
IDPs	Internally Displaced Persons
ILO	International Labor Organization
ITA	International Tin Association
ITSCI	International Tin Supply Chain Initiative
NSAG	Non-state Armed Group
ODK	Open Data Kit
OECD	Organization for Economic Co-operation and Development
SAEMAPE	Service for Assistance and Supervision of Artisanal and Small-Scale Mining
SAKIMA	Société Aurifère du Kivu et Maniema
ZEA	Artisanal Exploitation Zone

1 Introduction

Over the last decade, efforts to eliminate so-called "conflict minerals" have focused on denying access to world markets and global supply chains, aiming to break the link between illicit minerals extraction and the financing of armed groups. This strategy has been propelled by regulatory regimes in the United States (notably the 2010 Dodd-Frank Act) and, more recently, the European Union (EU), as well as more broadly at the international level via the Organization for Economic Co-operation and Development (OECD) Responsible Minerals Due Diligence Guidelines, which requires companies to conduct supply chain due diligence for gold and 3T metals (tin, tantalum, and tungsten) sourced from conflict-affected and high-risk countries.

In theory, denying illicit minerals trade access to world markets and global supply chains should limit the (financial) incentives of armed groups and other bad actors to attack, extort, or control mining activity. The strategy, however, wrongly presumes that we can separate out illicitly produced minerals; an impractical exercise near the end of the supply chain, as illicit ore does not carry any distinguishing markers. Due Diligence Programming (DDP) arose to overcome this challenge: intending to verify the origin of minerals and generate a chain of custody for ore from the mine to the smelters and refiners.

Despite its expansion, we still have limited evidence regarding the impacts of DDP on conflict and well-being in mining regions, like eastern DRC. Focusing on the immediate aftermath of the 2010 Dodd-Frank Act, several studies reached alarming conclusions, finding, for example, that armed conflict increased with the bill's passage (e.g., Parker and Vadheim, 2017). Yet, these studies do not isolate the effects of DDP; rather, they capture a bundle of policy changes, including a multi-year suspension of Artisanal and Small-scale Mining (ASM) across much of eastern DRC. A more recent policy report also attempted a comparison of mining areas in eastern DRC with and without DDP (IPIS/Ulula, 2019). Yet, that report acknowledges that its DDP and non-DDP groups differ along many dimensions, making it hard to attribute changes to DDP.

We advance this debate by offering more credible estimates of DDP's impacts. We gather original data from 104 mine sites in the provinces of South Kivu and Maniema, as well as surveys in neighboring communities from a representative sample of 1,054 household heads and 1,000 adults. To better isolate the effect of DDP, we employ a matching strategy, identifying 3T mining areas in our sample that are similar in terms of measurable characteristics except for the presence of DDP.[1] Our estimates of DDP's impacts, thus leverage comparisons of mining areas located in the same province and with similar geographies, histories of conflict, and development trajectories. In this way, matching helps us rule out many other factors besides DDP that might account for divergent outcomes.

[1] We focus attention on the ITSCI program, as it is the primary due-diligence program for 3T mines in eastern DRC.

Our analysis uncovers several important findings:

- First, DDP areas see lower rates of interference by Armed Forces of the Democratic Republic of Congo (FARDC); army units play important roles in the illicit networks that control or extort 3T mines (Matthysen et al., 2019). Households in DDP areas report 27% less FARDC presence and taxation relative to households in non-DDP areas (our control group).[2]

- Second, we find greater presence and more frequent activities of state mining agents in DDP areas. Households report that the Mining Division and Service for Assistance and Supervision of Artisanal and Small-Scale Mining (SAEMAPE) — the government agencies charged with oversight, technical support, and taxation — more commonly provide services and collect taxes. While households do not report more frequent demands for irregular payments from these state agents, informants at most DDP and control mines report instances of duplicative, excessive, or unlawful taxes. We also note that the influx of these state agents and the Mining Police (and the withdrawal of the FARDC) is not reflected in households' perceptions of safety; such perceptions do not differ between DDP and control areas.

- Third, we do not detect differences in the conditions of extraction. We record very few instances of forced labor in our matched sample, and have no scope to detect reductions.[3] Enumerators observed some child labor at roughly one third of mines covered by DDP, a rate not statistically distinguishable from control mines. DDP does not eliminate child labor, and we do not find a statistically significant improvement along this important dimension.

- Fourth, we find some weaker evidence of greater economic well-being among households in DDP areas, who report higher consumption levels. We cannot pin down the source of these differences; they could be due to the differences in FARDC and state presence, or the higher rates of employment in mining in DDP areas. We find no indication that DDP mines are more productive or can command higher prices for their ore, so it seems unlikely that DDP mines can afford higher wages.

- Finally, our representative sample of adults living in these mining communities includes men and women in equal proportion. Using these surveys to look at whether DDP has different impacts on men and women, we see similar effects, with two exceptions: (a) the increase in female respondents' knowledge of DDP is not as large as for male respondents in the DDP areas, likely due to their more limited employment in mining; (b) among women, DDP is associated nwith improved perceptions of ASM – specifically of its impacts on access to clean water, health, and general village life.

How one regards these differences depends on their benchmark for success. DDP is not perfectly implemented, nor does it eradicate unlawful taxation or labor

[2] Since activity from non-state armed groups is exceedingly rare in our matched sample during the study period there is no room for improvement.

[3] The International Labor Organization (ILO) definition of forced labor includes work or service that has been extracted under threat of penalty and has not been offered voluntarily. Measurement of forced labor sometimes includes questions regarding freedom of association, use of force or menace, and debt bondage or the withholding of wages. We did not separately ask about these dimensions; forced labor may, thus, be under-reported.

practices, including child labor.[4] Yet, along some important dimensions, DDP appears to foster meaningful improvements. Our household and individual surveys also uncover no evidence that people believe DDP to have unintended, adverse effects: perceptions of ASM's contributions to village life do not darken in DDP areas.[5] Detailed programming data on the scale-up of DDP in eastern DRC would permit a broader analysis than what we undertake here, including a consideration of cost-effectiveness.

The remainder of this report proceeds as follows: (1) we situate the study in the local context and existing literature on DDP; (2) we enumerate a set of hypotheses based on a theory of change posited by the OECD; (3) we describe our data collection; (4) we provide a descriptive analysis of our sample of mines, households, and individuals; (5) we outline our matching approach and its implementation; and (6) we report results from our matched analysis. We provide additional background and empirical detail in the appendix for interested readers.

[4] Child labor, as defined in Congolese Law and measured in this report, involves labor among children age 15 and under. We cannot further distinguish the "worst forms" of child labor in our surveys.

[5] Perceptions of ASM do not, for the most part, differ between DDP and non-DDP areas. In our individual surveys, we see more favorable perceptions in DDP areas of ASM's effects on health and the availability and cost of food.

2 Background

Eastern DRC comprises the provinces of South Kivu, North Kivu, Maniema, Ituri, and Tanganyika. Of the approximately 23 million people who live in the region, a majority reside in rural and peri-urban areas (INS, 2019). Our data collection and analysis focus on the provinces of Maniema and South Kivu.

Wars raged in the DRC from 1996 until 2003 (for additional historical background, see Stearns, 2012; Lemarchand, 2009). The first Congo War (1996–1997) put an end to the dictatorial regime of Mobutu Sese Seko.[6] The second Congo War (1998–2003), while initially launched to overthrow President Laurent-Désiré Kabila, devolved into fights over Congo's natural resources. Local armed groups abetted the removal of large flows of gold, coltan, and cassiterite (Turner, 2007). The 2001 Report of the United Nations Panel of Experts argued that revenues from illicit minerals finance armed groups in eastern DRC, which fuels and perpetuates regional conflicts. [7]

International initiatives have attempted to restrict the illicit trade of so-called "conflict minerals," specifically gold and the 3T metals (tin, tantalum, and tungsten, which are derivatives of cassiterite, coltan, and wolframite). Notwithstanding these efforts, armed or criminal groups continue to interfere in the production and trade of minerals and commit abuses.[8] Currently, the DRC contains 5.5 million Internally Displaced Persons (IDPs), with about 1.7 million new IDPs recorded in 2019, primarily in the provinces of South Kivu, North Kivu, and Ituri (IDMC, 2019).

While the minerals trade can contribute to conflict, eight to ten million people in the country also directly or indirectly depend on ASM for their livelihood (World Bank, 2010). In North and South Kivu, estimates range from 1 to 1.75 million people who depend on ASM (9–17% of the population in those provinces) (Geenen and Radley, 2013). ASM generates commerce and creates jobs that sustain many

[6] A coalition of Congolese rebel groups, directed by Rwanda, waged the First Congo War. Rwanda aimed to neutralize Hutu militias in North and South Kivu, which had fled Rwanda in the aftermath of the 1994 genocide.

[7] A peace agreement was signed in 2003 between the Congolese Government and several warring rebel groups, free elections took place in 2006, and larger rebel movements fragmented. However, a persistent governance crisis enables the proliferation of smaller (splinter) armed factions and groups of bandits, especially in eastern DRC.

[8] A 2019 report concludes that although most armed conflicts appear unrelated to mining, armed interference in ASM persists in remote areas, especially in the territories of Fizi and Shabunda in South Kivu (Matthysen et al., 2019).

families (Matthysen and Zaragoza, 2013).

2.1 Government Regulation of ASM Sector

ASM is regulated by the 2018 Congolese Mining Code (*Code Minier*), the Mining Regulation (*Règlement Minier*), and several ministerial decrees.[9] According to these laws, artisanal miners must hold a license, belong to a mining cooperative, and work in a so-called Artisanal Exploitation Zone (ZEA), designated by the Mining Cadastre (*Cadastre Minier*).[10] Many 3T mines fall outside of ZEAs, on industrial concessions held by Société Aurifère du Kivu et Maniema (SAKIMA), a state-owned mining company that has ceased production and now hosts ASM. SAKIMA has signed contracts with a number of mineral traders (*comptoirs*), granting some of them the exclusive right to buy minerals at validated mines within its concessions (Matthysen et al., 2019).

Two state mining services agencies directly oversee the ASM sector: the provincial Mining Division (*Division des Mines*) and Service for Assistance and Supervision of Artisanal and Small-Scale Mining (SAEMAPE). The Mining Division is charged with issuing cards to miners (*carte de creuseur*) and dealers (*carte de négociant*) and is responsible for ensuring that the mining operations comply with the law. SAEMAPE, on the other hand, provides technical support, training, and guidance to miners during mining operations; oversees safety, hygiene, and environmental practices at the site; and ensures miners belong to a mining cooperative. SAEMAPE also collects production statistics and is responsible for the traceability protocol at 3T mines. Both agencies serve on a joint validation team that confirms the absence of armed actors at mining sites and other risks outlined in the OECD's Due Diligence Guidance.[11] Only minerals from validated ("green") sites can be certified for export.

The Mining Division and SAEMAPE have the sole authority to collect taxes on mining activities. The Mining Division levies taxes or fees for miner cards, identification forms, and the use of certain equipment (e.g., motor pumps, washing infrastructure, etc.), or dynamite. SAEMAPE collects taxes and fees related to mineral production, identification forms, and registration forms.

[9] The 2002 Mining Code marked a renewed effort by the Congolese government to formalize the mining industry generally, and the ASM sector in particular. It was modified and updated in 2018 (Loi n°18/001 du 9 mars 2018). Other decrees include: Décret N° 038/2003 du 23 mars 2003 and Arrêté ministriel N°0058/CAB.MIN/MINES/01/2012 du 29 février 2012.

[10] The Mining Code limits ZEAs to areas that are unsuitable for industrial mining. The Ministry of Mines approves a new ZEA by ministerial decree after consultation with the provincial governor, the provincial Mining Division, and the Mining Cadastre.

[11] Validation teams also include representatives of the provincial government, international organizations in charge of the certification of minerals and of traceability, local civil society organizations, and United Nations agencies.

2.2 Due Diligence Programming

DDP entails ongoing monitoring of mineral production and processing to ensure that suppliers respect human rights and avoid contributing to conflict (OECD, 2016, p. 13).

Some minerals used in the manufacture of consumer goods (e.g., smartphones) originate from regions with limited state capacity and a history or high-risk of conflict, such as the eastern DRC. DDP arose from concerns that, in sourcing minerals from these areas, downstream companies could (unwittingly) contribute to financing human rights abuses or armed conflict. Under DDP, upstream produc-

ers (from mines to smelters) must have procedures to control and disclose risks associated with the production and transport of minerals. Downstream companies, for their part, must assess these suppliers' due diligence efforts and base sourcing decisions on risks they disclose or that have been independently identified.

DDP is required of all US-listed companies that source 3T metals and gold from the DRC and adjoining countries per Section 1502 of the 2010 Dodd-Frank Act. Similar legislation from the European Union requiring all importers of these minerals from "conflict-affected and high-risk areas" to undertake DDP takes effect in January 2021. These regulations all draw on guidelines promulgated in 2011 by the OECD.[12] The OECD framework has become the industry standard, and the specific risks it flags in Annex II guide on-the-ground monitoring efforts.

[12] China published voluntary standards in 2015 based on the OECD guidelines.

Over the years, a number of organizations have implemented DDP in gold and 3T artisanal mines sites in eastern DRC. Most notable are initiatives from the Federal Institute for Geosciences and Natural Resources (BGR), IMPACT, Tetra Tech, and the RCS Better Sourcing Program.[13] The International Tin Supply Chain Initiative (ITSCI) represents the largest program for 3T mines in eastern DRC. For this reason, and to limit variability in the program we evaluate, the DDP sites in our evaluation fall under ITSCI's program. Future research might compare the efficacy of different approaches to due diligence; however, such a comparison is not feasible in our study area. Whereas future lines of research might attempt to compare and contrast the efficacy of different types of DDP, sufficient data currently does not exist to compare DDPs via quantitative research methods.

[13] BGR, Impact, and Tetra Tech cover gold; IMPACT and Tetra Tech ceased operations in eastern DRC.

ITSCI grew out of an International Tin Association (ITA) working group established in 2008 and a small pilot in the eastern DRC in 2010.[14] ITSCI commenced full-scale operations in 2011 in Katanga, expanded to South Kivu and Maniema in 2012, and extended coverage to parts of North Kivu in 2014. As of 2020, ITSCI covered 2,306 mines across the DRC, Burundi, Rwanda, and Uganda (ITSCI, 2020).[15] ITSCI's protocol involves several steps. First, at a provincial level, ITSCI and state mining agents plan implementation for each province.[16] Even in provinces where it establishes programming, ITSCI cannot immediately cover all potentially eligible mines; rather, as funding permits, it incrementally scales up, extending coverage to new mining areas based on consultations with local authorities and available information and field resources. Second, individual 3T mines are assessed for eligibility. ITSCI conducts a baseline report at each eligible mine to check that the mine does not present Annex II risks and complies with local mining regulations. Third, after approval by ITSCI's Governance Committee, ITSCI initiates their chain-of-custody system (sometimes colloquially referred to as "bagging and tagging") to designate minerals as originating from a participating site. While ITSCI provides tags and initial training, SAEMAPE oversees bagging and tagging at the mining sites.[17] These state mining agents also collect taxes from artisanal miners and are mandated to provide services (e.g., technical and administrative support, formalization) that are not directly tied to ITSCI's programming. ITSCI consolidates and verifies the production data. Fi-

[14] Information regarding ITSCI's history and programming was assembled from multiple primary and secondary sources, including ITSCI (2011), Levin Sources (2015), ITSCI (2016), and ITSCI (2020).

[15] ITSCI members are active in 46 countries, and the Secretariat is based in the UK.

[16] ITSCI implements its on-the-ground activities through PACT, an international non-profit organization.

[17] The Mining Division and Center of Experts, Assessment and Certification of Precious and Semi-Precious Minerals (CEEC) are responsible for the tracing system at the exporter stage.

nally, according to ITSCI, it conducts ongoing monitoring, spot checks of participating mines, and manages an incident reporting and resolution system for incidents related to Annex II and other risks. ITSCI describes verifying and helping to resolve reported incidents in consultation with local authorities and committees.[18]

ITSCI acknowledges implementation challenges that result in deviations from this protocol. In particular, mines that do not participate in ITSCI use tags from other proximate and participating mines (Levin Sources, 2015, p. 88). This leads to the mixing of minerals that are and are not produced under ITSCI's DDP, risking supply chain contamination.[19] We document similar behavior in the mine-site surveys discussed below.

[18] We focus on aspects of ITSCI's protocol that directly affect mining communities in the eastern DRC. See here, for a more comprehensive description of ITSCI's programming, including their evaluation of companies, auditing, the chain-of-custody system, and stakeholder engagement.

[19] The improper use of tags (including fraud) is among the incidents that ITSCI reports tracking through its incident management systems (see here).

2.3 Existing Research on DDP

Debate continues over the impacts of DDP on conflict and economic development in eastern DRC. The existing academic research raises concerns about the unintended consequences of policies meant to better monitor mineral production in the region. Parker et al. (2016) find, for example, that armed conflict actually increased in the mining regions of the eastern DRC affected by the 2010 Dodd-Frank Act, relative to conflict in unaffected areas. Stoop et al. (2018) corroborate this finding over a longer study period: Parker et al. (2016) use data through 2012; Stoop et al. (2018) extend the data through 2015. Parker and Vadheim (2017) also find that infant mortality — a leading indicator of human development — worsened in mining areas where production was impacted by Dodd-Frank's "conflict minerals" provisions.

While carefully executed, these studies do not isolate the impact of DDP. Following the passage of the Dodd-Frank Act, the Congolese Government announced a ban on mining activity in three provinces: North Kivu, South Kivu, and Maniema. While this ban was lifted in March 2011, it was immediately followed by a boycott of minerals from the region. At that time, companies had limited ability to monitor production and, therefore, simply stopped sourcing from eastern DRC to avoid violating the provisions in Dodd-Frank. The changes the existing research document thus cannot be cleanly attributed to the rollout of DDP; rather — and this is something these authors clearly note — their results are driven by a multi-year suspension of legal mining and export activities in provinces that heavily depend on the mining sector. As noted above, ITSCI's programming for 3T mines only started in Maniema and South Kivu in 2012; it did not expand to North Kivu until 2014.

Our goal is to isolate the causal effects of DDP, rather than the bundle of policy changes and de facto industry boycott that immediately followed the Dodd-Frank Act's passage. Less empirical work has been done on this topic. A 2019 report from IPIS and Ulula identifies factors that correlate with DDP in eastern DRC, including an increase in state presence (IPIS/Ulula, 2019). However, it could not draw stronger conclusions about DDP's impacts, as DDP and non-DDP mines in

the sample differed along a number of other dimensions (e.g., non-DDP mines tended to produce gold; DDP mines produce 3T). We advance research in this field by restricting attention to DDP and non-DDP mines that are otherwise similar in terms of mine characteristics we can measure — comparisons where we feel more confident that differences in outcomes can be attributed to DDP. It remains possible that DDP and non-DDP mines differ in ways that we were unable to measure, which could bias our estimates.

3 Hypotheses

What effects do we expect DDP to have on security and economic development in mining areas?

DDP monitors mines and verifies that production meets minimum standards. This enables buyers (e.g., smelters and companies producing end products) to identify minerals originating from conflict affected and high-risk areas, such as the eastern DRC. These buyers can limit purchases to minerals produced at compliant DDP mines, thereby reducing demand for minerals produced at non-compliant or unverified — and, thus, potentially sub-standard — mines.

OECD (2016) provides an authoritative set of standards for due diligence around mineral production in conflict affected and high-risk areas (OECD 2016, see Annex II). Based on these standards, DDP mitigates the risks that mineral production (1) provides support to non-state armed groups or illegitimate security forces;[20] (2) evades legitimate taxes and fees; (3) pays bribes or misrepresents the origins of minerals; or (4) entails serious abuses (e.g., human rights violations).

[20] Annex II, paragraph 5 identifies a set of illegal activities that should not be undertaken by public or private security forces; paragraph 6 notes that these forces' sole responsibility should be to maintain order and prevent abuse. We regard security forces as "illegitimate" when their activities violate these criteria

Effective implementation of DDP should then have the following impacts:

1. Reduce taxation by non-state armed groups and illegitimate security forces;
2. Increase the payment of legitimate state taxes;
3. Reduce the payment of bribes; and
4. Reduce the serious abuses, including forced labor and the worst forms of child labor.

To assess whether these hypothesized effects actually occur, we evaluate outcomes related to each of these hypotheses.[21]

[21] Annex II provides a more detailed enumeration of these standards, which also include prohibitions on money laundering. Our evaluation does not look at possible impacts related to mitigating money laundering risks.

DDP could also have knock-on effects, positive or negative, on the economic well-being of miners and their communities. First, DDP could shift demand to verified mines, increasing prices or production volumes at those sites relative to unverified sites. However, it is not assured that any resulting price increases will be captured by miners; some recent work suggests that DDP may depress the bargaining power of miners.[22] Second, DDP could reduce the size and volatility of miners' tax payments by limiting extortion by armed groups or illegitimate security forces. This, of course, requires that any increase in taxation by state

[22] Multiple studies suggest that DDP raises the bargaining power of traders and depresses the prices paid to participating miners (Freudenthal, 2017; Vogel et al., 2017).

agents that accompanies DDP does not increase miners' overall tax burden.[23] Reducing interference by armed actors could have longer-run benefits for economic development, but only if it reduces insecurity, bolsters property rights, and thereby promotes private investment. We evaluate outcomes related to households' economic well-being, as well as several intermediate outcomes related to production and employment, to assess the net effects of DDP.

[23] Although DDP does not directly impose taxes on the miners, if it increases monitoring by state agents, it could indirectly increase the collection of taxes and fees. Research from Vogel et al. (2017) describes strategies developed by dealers (*négociants*) to evade these tax efforts.

To the extent that DDP affects the organization and oversight of an important economic sector, it likely has broader (potentially unintended) consequences for miners and mining communities. To provide a more complete picture, we explore several additional outcomes in our analysis, including whether DDP is associated with differences in how households perceive the mining sector's effects on the local environment, economy, and public safety, as well as the frequency of (fatal) injuries due to accidents at mine sites.

4 Sampling and Data Collection

4.1 Site Selection

We restrict attention to 3T mines in Maniema and South Kivu.[24] Between 2015-19, IPIS compiled data (including coordinates) for 349 3T mines in these provinces.

[24] The Ebola crisis and/or conflict in North Kivu and Ituri prevented surveying in these provinces.

We did not randomly sample from these 349 mines; rather, since our goal is to estimate the effects of DDP, we strategically selected our sample. We chose the 104 mines that maximized the properties (e.g., statistical power) of our empirical strategy (see Figure 1). On its own, this approach to site selection helped to mitigate the differences between DDP and non-DDP areas.[25] It excluded mines that we assessed ex-ante were non-comparable and unlikely to match counterparts in the opposing group.

[25] Table 10 shows a high degree of initial imbalance between DDP and control clusters when we use the full sample of 349 mines.

We confronted an unanticipated challenge prior to data collection: many more mines started participating in DDP. A large expansion of DDP, particularly within Maniema, severely restricted the number of potential control mines. Our final sample, thus contains more than twice as many DDP mines (73) than control mines (31). This is a limitation of our study; future research would benefit from historical, time-series data on the rollout of DDP and/or opportunities to build impact evaluation into new scale-up efforts.

IPIS identified 71 villages proximate to the 104 mines selected for our study. Many individuals working in the sampled mines live in these 71 "support" villages. These are also the communities that most immediately feel the knock-on effects — good and bad — of activity in these mines. In each of these 71 communities, we conducted 30 surveys: 15 households were randomly sampled, and we interviewed each household's head; within each of these households, we also randomly selected one adult for surveying. This two-step procedure generates representative samples of household heads and adults within these villages.

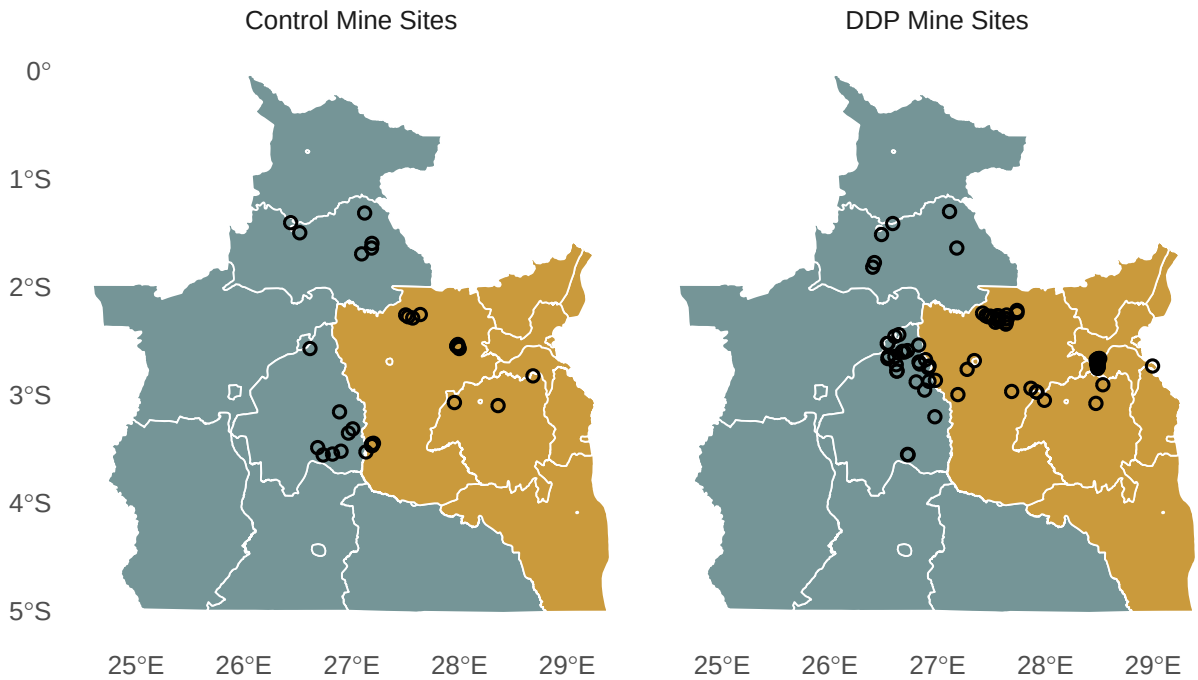

Figure 1: Location of Sampled Mines in South Kivu (Gold) and Maniema (Teal)

4.2 Survey Enumeration

IPIS led data collection, recruiting and training the enumeration team. IPIS selected enumerators based on their education and past experience with the ASM sector or survey efforts. The final team included 17 enumerators (14 men, 3 women); 10 had previously worked with IPIS on ASM in South Kivu and Maniema. Enumerators participated in a week-long training in Bukavu, South Kivu, organized by IPIS and Sub-Saharan Field Research and Consulting (SFR). Enumerators learned random walk protocols, interviewing techniques, safety protocols, questionnaire design, and the use of surveying devices (Open Data Kit (ODK) on smartphones and InReach satellite communicators).

Five survey teams (composed of 3–4 enumerators) deployed to the 71 sampled villages and 104 mines. From October 30 to December 28, 2019, these teams completed two missions (20–27 days each), surveying 1,054 households, 1,000 individuals, and 104 mine sites (see Table 1).

Enumerators followed strict safety procedures to minimize risks during data collection. The IPIS focal point in Bukavu supervised teams, tracking their movements through the InReach satellite communicator and each day requiring multiple status updates from every team. Enumeration teams assessed local security before entering a new mining zone by contacting local authorities, civil society representatives, and/or state mining officials. If given permission to survey, enumerators teams presented their mission order to the relevant authorities before beginning data collection. An incident report was prepared for all mining areas deemed too risky to survey.

Table 1: Completed Surveys

Province	Control	DDP	Total
Households			
Maniema	179	362	541
South Kivu	139	374	513
Total	318	736	1054
Individuals			
Maniema	179	357	536
South Kivu	129	335	464
Total	308	692	1000
Mine Sites			
Maniema	14	32	46
South Kivu	17	41	58
Total	31	73	104

To ensure respondents' safety, enumerators clearly informed them about the purpose of the survey and study. They also explained to interviewees that participation would be anonymous (that their names would not be registered) and voluntary, sought informed consent, and let the respondent know that they could stop the interview and withdraw their consent at any time.

4.3 Mine-site Surveys

Two enumerators identified key informants and conducted interviews at the mine site and the closest village to the mine.[26] At mine sites, enumerators spoke with miners, mine and pit managers, representatives of cooperatives, and/or traders. In the villages, they spoke with local authorities, civil society actors, state agents, traders, and/or mine managers. Each enumerator interviewed at least two key informants. The enumerators then met to discuss and compare their findings. (If they could not reconcile the information they independently gathered on a specific topic, they conducted additional interviews on that topic). They then collaboratively completed the survey questionnaire, generating a single survey for each mine site. For larger mines, enumerators spent around one day conducting interviews, whereas a half day of surveying sufficed for smaller sites (with less than 10 miners).

[26] If a risk assessment deemed the mine sites too dangerous to visit, key informant surveys took place in a nearby village or trading center.

4.4 Household and Individual Surveys

To select households for interviews, enumerators followed a random walk protocol in each sampled village. Enumerators sketched a map of the village, divided it into quarters, and randomly selected two quarters to survey. Heading out from the center of the village towards one of the selected quarters, enumerators counted houses on the left-hand side of the path and would select a household to survey based on the day of the month. On the sixth or fifteenth days of the

month, for example, enumerators counted six houses and surveyed the seventh, from that point onward they would survey every fifth household.

Enumerators interviewed the head of household or, if unavailable, their spouse. Household surveys lasted 30–45 minutes on average. However, if no consenting adults were available to be surveyed (less than 2% of cases), a new household was selected following the random walk protocol. Once the household survey was completed, the survey software randomly selected another adult member of the household to interview. This person would then be asked to provide informed consent and complete an individual survey, typically lasting 10–30 minutes. If no adult members of the household could complete the individual survey, another household would be selected via the random walk. Respondents received no compensation for completing a survey.

The random walk and subsequent random sampling of adults within surveyed households produced samples that are representative at the village-level. This constitutes an improvement over past work that relied on convenience samples from mobile phone surveys, which likely over-represent the views of certain types of respondents (e.g., mobile phone owners).[27]

As implied by this protocol, we did not intentionally over-sample households at risk of child or forced labor, and the goal of this study is not to estimate the exact prevalence of forced or child labor. As we note above, we do not directly measure some dimensions of forced labor (e.g., debt bondage); we rely instead on respondents' appraisal of whether work has been forced. It is also possible that child labor is also under-reported, as we do not directly survey children. Moreover, some informants at mine sites may be reticent to disclose child labor, despite enumerators' efforts to triangulate this information.

[27] In complementary work, Ulula is conducting a mobile survey of these households. That effort aims to characterize non-response bias in mobile surveys and potentially better measure some sensitive or fast-changing outcomes. We note that 42% of household heads report owning a mobile phone. We estimate that 23% of all adults own a phone, ranging from 0–53% across villages.

5 Sample Characteristics

Before launching into our matching analysis, we provide a brief quantitative summary of our sample of mine sites, households, and individuals. We include additional details in our appendix. Unless otherwise noted, the sample characteristics we present in this section refer to both DDP and non-DDP sites. We defer comparisons to DDP and non-DDP sites until after we have introduced and implemented our matching algorithm.

5.1 Mine Sites

As shown in Table 1, our sample includes 104 3T mines: 58 in South Kivu and 46 in Maniema; 73 covered by DDP and 31 not.[28] Four mines (all in South Kivu) were not active when enumerators visited.[29] Of the 104 mines, 9% were in a preparatory phase, 55% were partial production capacity, and 37% were at full production capacity.

[28] In South Kivu, we sampled mines from the territories of Shabunda (71%), Walungu (21%), Mwenga (7%) and Kabare (2%); in Maniema, from Pangi (74%) and Punia (26%).

[29] Two mines were temporarily closed due to financial and security issues, and two mines were abandoned.

Mineral Production

Nearly all mines (95%) produce cassiterite. A majority exclusively produce cassiterite (74 sites), while a smaller share also produce other minerals, including gold (7 sites), wolframite (6 sites), and coltan (18 sites). These mines employ different techniques: open-pit alluvial mining (66 sites); open-pit eluvial mining (48 sites); and shaft mining (36 sites).[30] (These percentages do not sum to 100%, because sites often combine techniques.) Although regulations forbid pits deeper than 30 meters, 3 sites violated this provision. Most mines rely on minimal mechanization, using pickaxes and shovels. 32% of mines display moderate or high levels of mechanization, employing jackhammers; motorized pumps; or, at the highest end of the scale, crushers and ventilation systems.

[30] Alluvial mining targets sediments transported by flowing water and deposited near rivers, eluvial mining targets secondary placer deposits on hillsides, and shaft mining involves underground mining.

Employment and Compensation

Mines employ more workers in Maniema than South Kivu: on average, 117 workers in Maniema (median: 90) and 72 in South Kivu (median: 34.5). Informants in 79% of mines report that employment levels fell in the last year. In Maniema, this could relate to the Government's suspension of ASM in underground mines after a fatal accident; no acute cause was noted in South Kivu, though metal prices (especially for tantalum) were relatively low.

From our sample of 104 mines, managers pay miners in minerals (53 sites), cash (35 sites), or a mix of minerals and cash (16 sites). This differs across the provinces. In South Kivu, miners tend to be paid in minerals only (86% of sites), whereas in Maniema a majority of sites (65%) pay workers in cash (see Table 8 for a more detailed breakdown).[31]

[31] We did not randomly sample mines, so these cross-province comparisons are only suggestive.

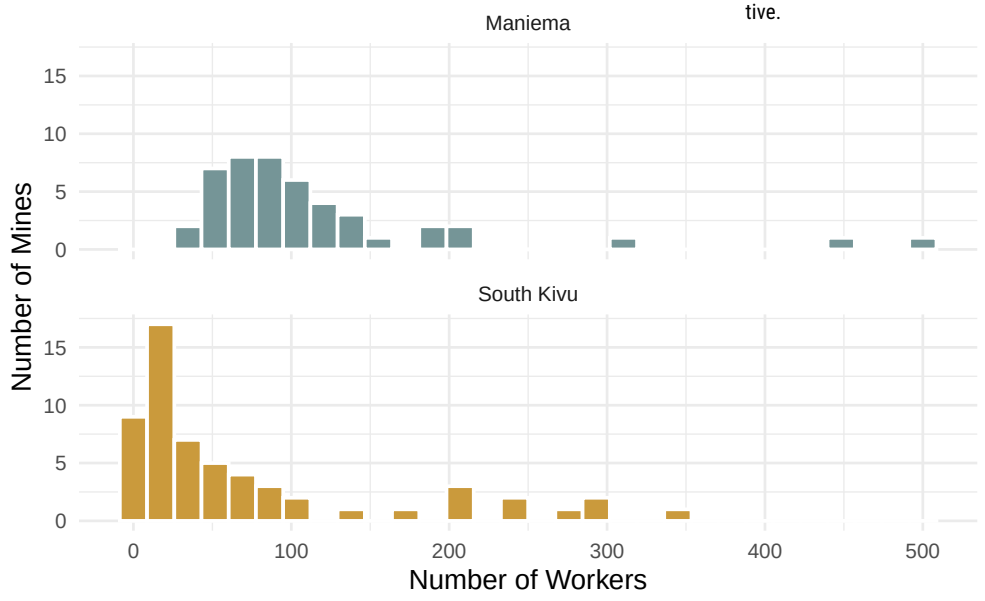

Figure 2: Number of Workers

Women in ASM

Women play an essential role in the ASM sector, by both mining and selling services to the mine and miners. We record 1,891 women at mine sites across 69 sites. We observe sharp differences in women's participation across provinces: women participate at 45% of mines in South Kivu and 93% of mines in Maniema. Where they are employed in mining-related jobs, women serve as diggers and perform less-remunerated support work, such as washing, treating tailings, transport, and crushing minerals. At most active mines, women sell goods including food (68 sites), and other consumable goods (38 sites). They also provide services to the mines and miners, such as running a restaurant (55 sites), and sex work (50 sites).

Children in ASM

The 2009 Congolese Law on Child Protection prohibits employment of children under 16 and the worst forms of child labor, including hazardous work "that by its nature or the conditions in which it is carried out, is likely to harm the health, safety, dignity and morals of the children."

Informants reported 363 children below the age of 16 at 30 active mines, including both DDP and non-DDP mines.[32] (We analyze DDP's effects on child labor below.) They participate in digging (26 sites), washing (27 sites), treating tailings (20 sites), transport (7 sites), and crushing (1 site). Children do not attend school at all in 14 sites; they combine work and school at 16 sites.

Armed Actors' Presence and Interference

We detect non-state and, to a greater extent, state armed actors at mine sites. In South Kivu, informants reported interference by the Non-state Armed Group (NSAG) Raia Mutomboki (Raia, for short) at 5 sites and the Mai Mai Malaika Militia at 2 sites.[33] [34] While Raia did not maintain a permanent presence at these sites, the group levied taxes, pillaged (3 sites), and perpetrated sexual violence (2 sites). [35] Raia interference was observed at a non-DDP and DDP sites. The Mai Mai Militia erected roadblocks to tax mineral production and transport.

Informants in 21 sites report the presence of the Congolese Army (*Forces armées de la république démocratique du Congo* or FARDC) over the last six months. This includes both DDP and non-DDP sites; we analyze differences between DDP and non-DDP mines in terms of FARDC presence below. In 11 of these sites, informants noted at least monthly visits from the FARDC; in 10 sites, their presence was less frequent. The FARDC interfered in 17 of these sites, most often engaging in illegal taxation (14 sites) and, more rarely, coercing forced labor (3 sites) or assuming ownership of a pit (1 site).[36]

Matthysen et al. (2019, p. 53) note that armed criminal networks continue to interfere with ASM and that "the main armed faction within these criminal networks are often Congolese army units." However, the FARDC has also been deployed in eastern DRC to neutralize non-state armed groups and provide stability. In 2017 and 2018, for example, the FARDC fought Raia in northern Shabunda

[32] ITSCI, through its implementing partner PACT, reports mitigation and remediation activities related to child labor. They describe awareness-raising campaigns among miners and key stakeholders to explain the regulations and harms related to child labor. If child labor is detected at a mine participating in DDP, PACT reports that they complete an incident report, refer the matter to state agents, and conduct additional awareness-raising around the offending site.

[33] Raia Mutomboki is a local self-defense militia, created to defend villages in Shabunda territory against attacks of other armed groups, particularly the Democratic Forces for the Liberation of Rwanda (FDLR).

[34] The Mai Mai Malaika is an armed group that initially organized to oppose the Banro Corporation, a Canadian mining company. In 2017, they joined a coalition of Mai Mai movements in eastern DRC called National Coalition of the People for the Sovereignty of Congo (CNPSC), and operate in the border area between the provinces of Maniema and South Kivu (Congo Research Group, 2019).

[35] To avoid confrontations with the Mining Police at the mine site, Raia Mutumboki members sometimes wait until mine managers are off site to demand payments. Informants reported this happening with two mine managers in Walungu territory.

[36] These instances of forced labor and pit ownership were recorded at mines covered by DDP.

(South Kivu). After this offensive, FARDC units remained in the territory. For this reason, some feel that the FARDC enhances local security. Anecdotally, FARDC soldiers in South Kivu (Mwenga territory) provided on-demand security for miners in return for a fee (Matthysen et al. 2019: p. 51).

State Agents' Presence and Performance

Informants recorded the presence of the Mining Division and SAEMAPE over the six months prior to data collection in 81 and 88 active sites, respectively. The Mining Division visits 15 active sites at least weekly and 42 at least monthly; other sites were visited less frequently. SAEMAPE maintains a more regular presence, visiting 27 active sites at least weekly and 47 at least monthly. Yet, SAEMAPE agents were still not present or only occasionally visited more than half of active sites. Only 18 sites receive support from the Mining Division; 32 of active sites receive technical support from SAEMAPE.

The Mining Division collects taxes at 55 sites, in addition to collecting data on production; supporting miners; and, in 6 sites, informants reported agents from the Mining Division exploiting their own mining pits. SAEMAPE levies taxes in 76 sites, while also collecting data on production; providing support to miners; and, in 8 sites, informants reported SAEMAPE agents exploiting their own mining pits. With both entities collecting taxes, we document reports of double taxation — miners charged twice for the same document or service. Informants also report being charged for taxes that have no basis in law (e.g., an "arbitrary tax", a "tax on declaration of the pit").

As noted above, the Mining Division and SAEMAPE have the sole authority to levy taxes at mines. However, informants reported 9 other government agencies levying taxes across 29 active mines in the six months prior to data collection.[37]

[37] The 9 additional agencies collecting taxes are: *Agence National de Renseignements*, *Comité National de Protection des Rayonnements Ionisants*, *Direction Générale des Recettes du Maniema*, *Direction Générale des Impôts*, *Police des Mines*, *Direction de la Pharmacie et du Médicament*, *Direction Générale des Recettes Administratives Domaniales*, and the administrative entities *chefferie* and *secteur*.

5.2 Households

We conducted in-person surveys with household heads in 71 villages; in total, we surveyed 1,054 households (see Table 1).

Most households (83%) comprise a single family; only 17% include unrelated people living in the same house (e.g., migrant workers). The average household includes 3.4 members (median: 3). Households heads are predominantly (87%) male and have an average age of 42. The vast majority (88%) have lived in the village for their entire life; only 3% have resided in the village less than one year. While 16% report no formal education, 29% attended primary school; 49%, secondary school; and 6% have some tertiary education. Nearly all (95%) heads of household are employed. Figure 3 provides counts of household heads working in mining and non-mining occupations.[38] 39% report mining as their primary source of income. The next largest sector is agriculture: 38% of household heads work in farming.

[38] Respondents can indicate multiple jobs performed at the mine site. The sum across categories can, thus, exceed the number of respondents.

To better understand how ASM affects communities, we asked household heads to assess the effect that ASM has on the quality of air and water, health,

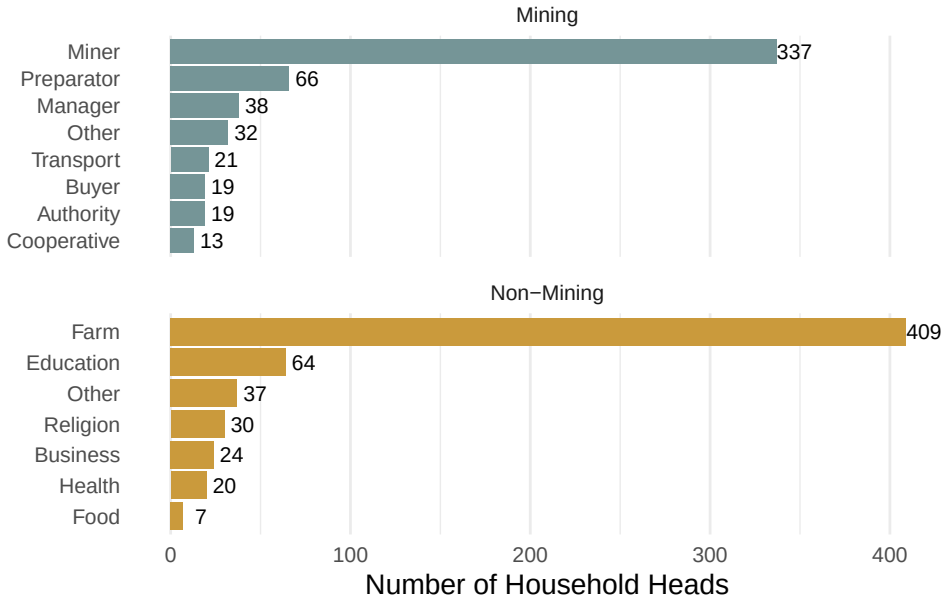

Figure 3: Occupations of Household Heads

food prices, local jobs and businesses, safety and security, and relations between people (cohesion), as well as its overall effect. We employ a five-point likert scale that varied from "Very Negative" to "Very Positive." We summarize these responses in Figure 4: 59% express that mining, in general, has a positive overall impact on their lives in their villages; 19% felt the overall impact was negative. A majority feel that ASM has a positive effect on many facets of village life, including jobs and businesses (64%) and public safety (72%).[39] The only exception is the environment: 55% feel that ASM has a negative or neutral effect on the quality of water.

[39] Households that negatively perceive ASM's effects on safety are more likely to report attacks by NSAGs, extortion attempts by NSAGs, and clashes between NSAGs and the FARDC (see Figure 9).

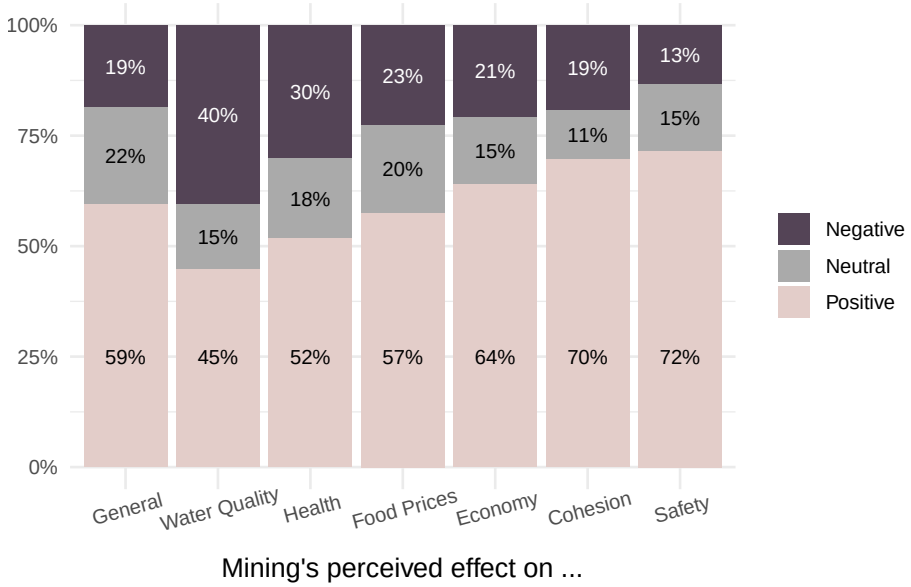

Figure 4: Perceptions of Household Heads

5.3 Individuals and Gender Differences

We randomly selected an adult within each household (including the household head) and administered a separate survey, interviewing 1,000 respondents. This procedure generated gender balance among respondents allowing us to better describe the characteristics of women living in these mining communities.

In Table 2, we summarize demographic characteristics by gender and province. The most striking differences between men and women relate to education and employment. Women in both provinces report having no formal education three times as often as male respondents. Women are also somewhat less likely to report that they are currently working and much less likely to report that their primary income comes from a job in the mining sector. While 10% of women in South Kivu work primarily in the mining sector, 44% of men hold a mining job.

Consistent with the household surveys, we find few individuals (5% of all individuals) who have recently moved to the village, suggesting relatively low rates of inmigration.

Table 2: Characteristics of Individuals

	Female	Male
Respondents	503.00	497.00
Basic Demographics		
Age	33.46	36.53
< 1 Year in Village	0.05	0.04
Education		
No formal Education	0.37	0.12
Primary	0.35	0.28
Secondary or beyond	0.29	0.60
Employment		
Employed	0.86	0.91
Primary Job: Mining	0.13	0.47

Finally, we explore whether men and women living in the same village hold similar beliefs about ASM's impacts. In Figure 5, we compute the percentage of men (horizontal axis) and women (vertical axis) in each village who feel that ASM has a positive overall impact on their community. (We include a dashed 45-degree line for reference.) In general, these shares are highly correlated. Yet, we see some differences across provinces: in 58% of villages in Maniema women feel more positively than men; that is true of only 35% of villages in South Kivu.

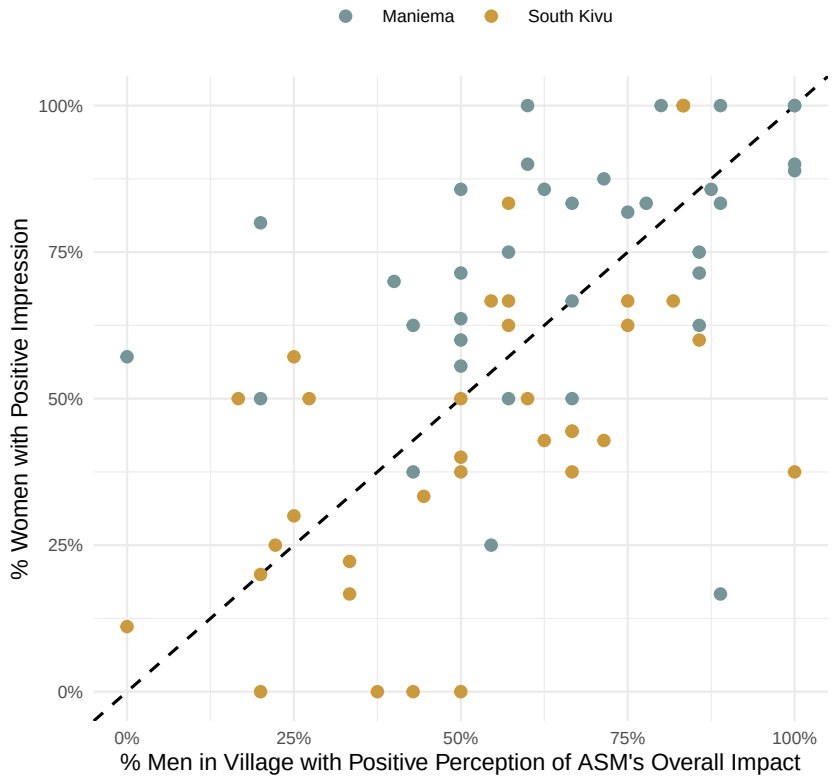

Figure 5: Gendered Perspective on ASM's Impacts

6 Empirical Approach

6.1 Motivation for Matching

We aim to estimate the difference in outcomes that can be solely attributed to DDP: the causal effect of DDP. Yet, the mining areas that do and do not receive DDP may differ in a number of other ways besides the presence of DDP. Indeed, using a sample of 349 3T mines that IPIS surveyed prior to 2019, we find that DDP is more often present in mining areas that were more developed and populous before the advent of DDP. When we compare areas with and without DDP, it could be these initial differences, and not DDP, that explain any divergence we find in present-day outcomes.

Ideally, we would conduct a large-scale randomized experiment to ensure that the areas that do and do not receive DDP are otherwise comparable. We employ matching as a second-best approach: in short, it allows us to focus our comparisons of DDP and non-DDP areas on those that are similar in measurable ways. Matching takes the set of places that received DDP, and selects a set of places that did not receive DDP but are otherwise similar. The critical assumption is that, after matching, there are no residual differences between DDP and non-DDP areas that could generate differences in outcomes. Importantly, differences may

remain in terms of characteristics we cannot measure. Put differently, if we omit relevant variables from our matching algorithm, our estimates will not isolate the causal effect of DDP.[40]

[40] Relevant variables are those that predict treatment assignment (i.e., whether an area receives DDP).

6.2 Matching Algorithm

Our matching algorithm involves three steps:

1. **Collect Pre-DDP Characteristics.** We draw a circular buffer around each mine that is 2 kilometers in radius. Overlaying these buffers on pre-program (prior to 2012) geospatial data, we can measure characteristics of each mine. We measure, for example, the number of roads near a mine by counting the number of roads that intersect the 2-kilometer buffer around that mine. This first step generates a dataset of pre-treatment characteristics for each mine.

2. **Geographically Cluster Mines.** Where multiple mines operate in close proximity, we group these proximate mines into a single cluster.[41] This places the 104 mines in our sample into 68 clusters: 44 clusters contain a single mine; 16 clusters contain two mines; 4 clusters contain three mines; and 4 clusters contain 4 mines. No mine falls within two kilometers of another mine that is not in its same cluster. We consider a cluster to be "treated" by DDP if any mine within the cluster participates in DDP. Control clusters thus contain no participating DDP mines, whereas treatment clusters can contain non-participating and/or non-compliant mines. This alleviates concerns that our control mines neighbor participating mines and, thus, are indirectly treated due to spillovers.[42]

[41] This reflects our understanding of how DDP rolled out. It did not target specific mines, but rather initiated activities in an area at the request of local stakeholders. We take our clusters to approximate the unit of assignment and cluster our standard errors at this level.

[42] In our matched sample, 89% of clusters only include either DDP or non-DDP mines; only five treated clusters contain both DDP and non-DDP mines. We code clusters as treated if they contain a single DDP mine to limit spillovers to our control units: non-DDP mines operating in the same cluster as DDP mines may be indirectly treated (e.g., through the increased presence of state agents in the area) and thus fail to provide a good estimate of conditions absent DDP (i.e., in control).

3. **Matching Clusters using Coarsened Exact Matching.** We aggregate the characteristics we measured for each mine to the cluster-level and then match using these cluster-level characteristics. We exactly match on province (ensuring that clusters are matched to others in their province only), the presence of cassiterite mines, and the presence of coltan mines. We employ Coarsened Exact Matching (CEM) for other characteristics, which involves recoding continuous variables into discrete categories (i.e., binning) and then exact matching on those categories. Coarsened exact matching generates a set of weights: unmatched observations (clusters) receive zero weight; matched treatment observations receive weights of 1; and matched control observations receive positive weights.[43] We estimate the sample average treatment effect on the treated by regressing outcomes on treatment using these weights. We refer to this estimate as "DDP Impact" in what follows.

[43] If a control observation is matched to multiple treated observations (as is common in matching), that observation can receive a weight larger than 1.

6.3 Pre-treatment Characteristics

We use publicly available geo-spatial data to construct pre-DDP characteristics. These fall into several categories:

1. **Conflict.** We use data from the Armed Conflict Location and Event Data (ACLED) to measure the number of armed conflict events and associated fatalities near each mine from 2007-2011.

2. **Economic Development.** We employ data on motorable roads from the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). We use remotely sensed nighttime lights measured in each year from 2007-2011, which is a common proxy for economic development.

3. **Geography.** We measure the average elevation and slope and number of rivers around each mine.

4. **Mining.** Using data previously collected by IPIS, we code whether a mine produces cassiterite and/or coltan.

5. **Administrative.** We use each mine's geo-coordinates to place the mine within a specific province (Maniema or South Kivu) and territory.

6.4 Matched Sample

The matching algorithm retains 43 comparable clusters from the original 68. The overall and matched samples are both imbalanced with respect to the presence of DDP: only 26% of clusters contain no mines participating in DDP; this proportion increases to 35% in the matched sample.[44] The 43 matched clusters contain 58 mines and roughly 700 households from the initial sample (see Table 3).

[44] The same control cluster can be matched to multiple treated clusters.

Table 3: Matched Sample

Status	Matched	Unmatched	Total Clusters
Control	15	3	18
DDP	28	22	50
Total Clusters	43	25	68

The remainder of the report focuses on the subset of mine sites, households, and individuals included in our matched sample. Rates in this subset may differ from figures reported in the "Sample Characteristics" section.

This matching improves the comparability of our DDP and non-DDP clusters. Both for variables included in the matching as well as additional characteristics, we find a high degree of balance (see Table 11. Prior to matching, for example, we estimate that DDP clusters in our sample had, on average, twice as many people (669 vs. 257) and were more likely to be located in South Kivu; after matching, the population difference shrinks to just three people and there are no differences in the distribution across province.[45]

[45] In addition to the balance tests for individual covariates, we also run an omnibus test, regressing our treatment indicator on all available covariates. The F-stat from that regression is 0.54 ($p = 0.85$), which indicates that any residual differences in covariates do not jointly predict treatment. Working with the larger sample of 3T mines that IPIS surveyed prior to 2019, we employ the same test and find significant imbalances ($p < 0.001$).

We note that the matching excludes the few clusters that experienced armed conflict from 2007-2011 (This is because there are no control clusters with similar histories of past conflict, and thus no matches). This bears on the interpretation of our results; our sample does not include clusters that, according to ACLED,

experienced armed conflict. As a consequence, our estimates do not (without further assumptions) characterize the impact of DDP in mining areas with armed conflicts immediately prior to DDP's launch, between 2007 and 2011.

6.5 Index Creation

To gain statistical power and summarize multiple variables that measure a common concept, we sometimes combine related survey items into control-group standardized indexes. This involves standardizing (i.e., creating a z-score) each item using the matched control group's mean and standard deviation, and then averaging the standardized items to create a single index value. Given this procedure, the control group average for these indexes is always zero, and effect sizes for indexes are in standard deviation units (i.e., relative to the baseline variation).

7 Results

7.1 Implementation of DDP

We start by assessing the presence and salience of DDP; these programs cannot affect other outcomes if they are never meaningfully implemented. Using both the mine-site and households surveys, we find greater knowledge of, and activity related to, DDP in our treated clusters. In Table 4, we find that mines in control clusters report no visits related to ITSCI's program.[46] Yet, nearly all (97%) mines in DDP clusters report at least some visits from ITSCI or the state agents responsible for administering DDP; 43% report receiving at least monthly visits since joining the program. State mining authorities (SAEMAPE or the Mining Division) received training related to traceability at 78% of mines in DDP clusters but only 33% of mines in our control clusters — a difference of 45 percentage points (pp) or 136%. Among households surveyed in DDP clusters, 57% have heard of due diligence (25% know ITSCI by name), and 56% report seeing minerals tagged in the last three months, more than double the rates in control clusters.

[46] Tables in this section follow a common format: "Control" reports the average in control clusters; "DDP Impact," the difference between treated and control clusters; "SE" and "p" the standard error for this difference and the p-value; and "N" and "Clusters" the number of observations and clusters used to estimate these quantities. In the social sciences, $p < 0.1$ is commonly used as a threshold for statistical significance.

Table 4: DDP Implementation

Variable	Control	DDP Impact	SE	p	N	Clusters
Mine Sites						
SAEMAPE or Mining Division received training on traceability	0.33	0.45	(0.13)	0**	58	43
At least monthly visits from ITSCI	0.00	0.43	(0.1)	0**	58	43
Households						
Heard of due diligence programs	0.25	0.32	(0.09)	0**	738	43
Mentions ITCSI's due diligence program	0.06	0.19	(0.07)	0.02**	650	43
Tagging mineral bags	0.26	0.41	(0.09)	0**	624	43
Tagging occurred 3 or less months ago	0.19	0.37	(0.08)	0**	624	43

This evidence regarding implementation also informs how we interpret sub-

sequent results. In particular, our estimates of DDP's impacts may be lower than the true impact of the program for two reasons. First, we observe traces of DDP in control clusters. For example, 26% of households in control clusters report seeing minerals bagged and tagged, nearly 20% in the last three months. This could be due to the fraudulent use of tags by control mines. Alternatively, households from control clusters may observe the tagging of minerals from participating mines at a nearby trading center. Second, since we define a cluster as treated if any mine contained in that cluster participates in DDP, a treated cluster can thus contain non-DDP mines. Our control clusters may be partially treated, and some of our treated clusters receive a less than full "dose" of DDP. These features are not damning for the interpretation of our results; rather, they imply that our estimates of DDP's impacts may be conservative.

Finally, while DDP is significantly more present and salient in treated clusters, we do detect challenges with implementation. Some mines in treated clusters, for example, report that the first instance of bagging and tagging does not occur at the mine site (including the area where minerals are washed). Rather, it occurs in trading centers, at a remove from the site, which risks contamination of the supply chain. In control clusters, most mines report having illegitimately acquired tags from DDP mines. At mines covered by DDP, enumerators observed tagging of minerals from non-participating mines; they also reported tags being sold in parts of Maniema (at 1,000 Congolese Francs).

7.2 FARDC Interference and State Presence

We first hypothesized that DDP would reduce taxation by non-state armed groups and illegitimate security forces. As noted above, our matched sample does not include mines with a recent history of armed conflict, and we detect virtually no activity from non-state armed groups in our control clusters. There is, thus, no scope for reductions in our sample.

We do, however, find substantially lower reports of FARDC presence and taxation at mines. While 48% of mines in control clusters report visits from the FARDC in the last six months and 39% report illegal requests for "taxes", only 20% of mines in treated clusters report recent FARDC presence and 14% report requests for taxes (see Table 5). Those represent roughly 60% differences in both FARDC presence and taxation at mines in DDP clusters.

Table 5: Illegal Taxation at Mines

Variable	Control	DDP Impact	SE	p	N	Clusters
Identified Armed Groups (Raia) in mine site (last 6 mos.)	0.01	0.00	(0)	0.45	58	43
Armed Groups (Raia) requesting taxes in mine site (last 6 mos.)	0.01	0.00	(0)	0.45	58	43
Identified FARDC in mine site (last 6 mos.)	0.48	-0.28	(0.11)	0.02**	58	43
FARDC requesting taxes in mine site (last 6 mos.)	0.39	-0.25	(0.13)	0.07*	58	43
Evidence of a form of illegal state taxation	0.65	0.00	(0.16)	1	58	43

This result is corroborated in the household surveys. Among households living in DDP clusters, we note a 27% (18 pp) lower rate of respondents reporting that the FARDC is present in their village and a 38% (10 pp) lower rate of households reporting presence by the FARDC at nearby mines, though the latter difference is not statistically significant (see Figure 6). Reports of tax collection by the FARDC along nearby roads are also lower by over 59% (13 pp) in DDP clusters (see Table 13).

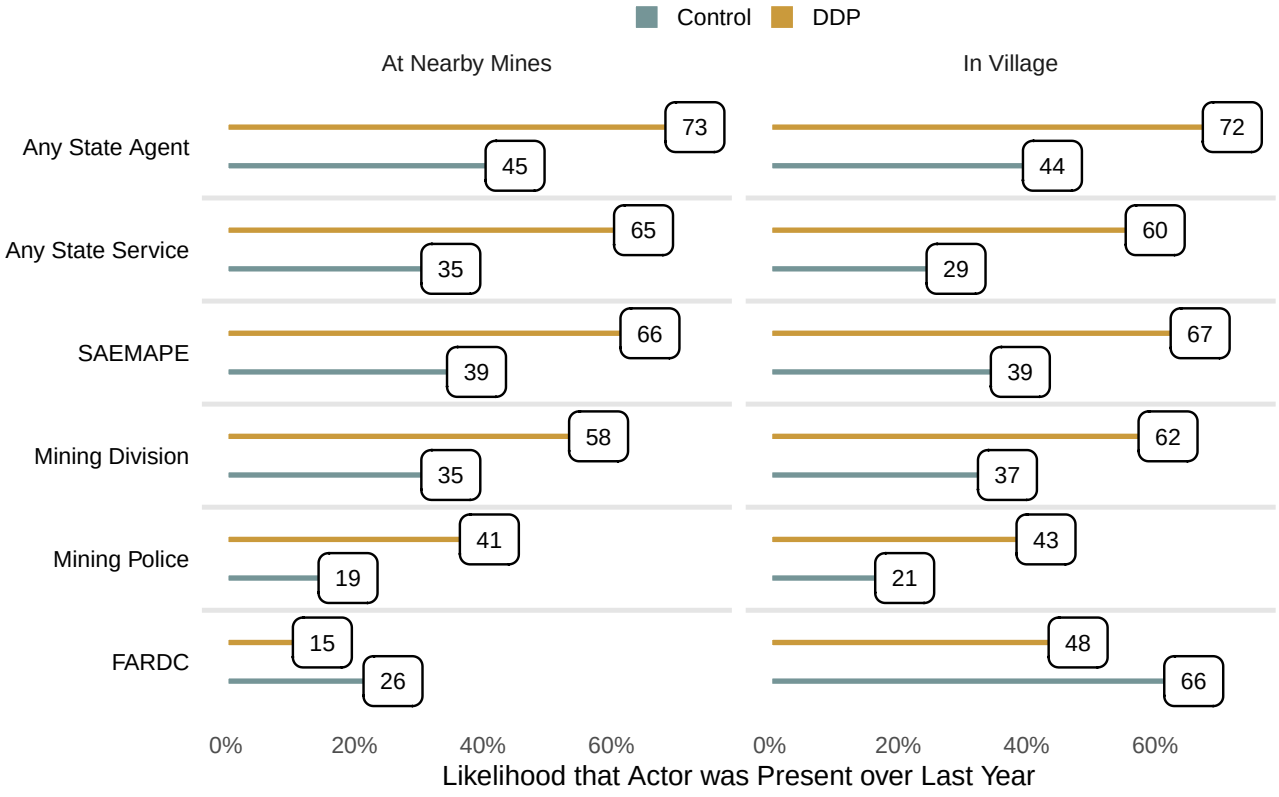

Figure 6: Presence of State Agents

While DDP intends to limit extortion by armed actors, it promotes the oversight and taxation of mining activity by legitimate state authorities. As the FARDC pulls back, we find clear evidence of greater state presence and taxation in DDP clusters. Households in DDP clusters are more likely to report seeing SAEMAPE, the Mining Division, and the Mining Police in their villages, as well as at nearby mines over the last year (see Figure 6): we observe, for example, a 72% (28 pp) higher rate of households noting SAEMAPE agents in their village over the last year; the presence of the Mining Police more than doubles.

The heightened presence of these state authorities — SAEMAPE, the Mining Division, and the Mining Police — is associated with greater taxation: 39% of households in DDP clusters report taxation by these state agents in their village, compared to just 20% of households in control clusters (see Table 13). Households in DDP clusters also report a 58% (19 pp) higher rate of tax collection by these authorities at mines near their villages. Yet, while the likelihood of tax-

ation more than doubles, we do not find a statistically significantly higher rate of reports of irregular payments to these state agents (including traditional authorities) among households in DDP clusters. Across DDP and control clusters relatively few households report making irregular payments. When asked about illegal taxation by state agents (e.g., SAEMAPE, the Mining Division), at least one informant at 65% of mines in both DDP and control clusters reports a form of illegal taxation in the last six months (see Table 5).[47]

State authorities collect more in taxes, and also provide additional services in DDP areas: 60% of households report some service delivery by these state agents in the last year, which is more than double that of households in control clusters (29%). Households report that these agents conduct inspections and work to detect fraud, provide training, and help formalize artisanal mining activity.[48] Despite increases in service provision, in a majority of active mine sites, informants feel dissatisfied with services or report that the state agents do not fulfill their prescribed roles (e.g., visiting infrequently, failing to provide technical support).

Table 6 constructs indexes using measures from the household survey. Summarizing several key results, we find a significantly lower rate of FARDC interference in DDP areas. By contrast, state authorities assume a greater role in these communities, collecting taxes and providing services without making significantly more demands for irregular payments from households. Despite this higher level of state presence, households in DDP clusters report feeling neither safer, nor that mining has a more positive impact on their community.[49] The same is true when we look at the individual surveys and look separately at responses among men and women: there are no improvements in perceived security.

Table 6: Change in State Presence and Services

Index	DDP Impact	SE	p	N	Clusters
Interference from FARDC	-0.33	(0.17)	0.08*	738	43
State presence and services	0.65	(0.15)	0**	738	43
Taxes: State Agents	0.49	(0.16)	0.01**	700	43
Irregular payment to state agent	0.17	(0.19)	0.4	737	43

Note: Table 13 reports results for the variables used to construct these indexes.

7.3 Conditions of Extraction

DDP is meant to ensure that mines do not rely on forced or the worst forms of child labor. In our sample, reports of forced labor are extremely rare; across our control clusters, a single respondent (of 288) reported that a member of their household had been forced to work in a mine in the last year. This obviously leaves little scope for DDP to reduce the incidence of forced labor in our sample (see Table 7).

[47] Illegal taxation, as coded here, includes taxation by an agent that is not allowed to tax, double taxation (the same tax imposed by different agents); taxes for documents for which miners should not pay; and/or overtaxation.

[48] Formalization requires miners' time, subjects their actions to increased scrutiny, and adds financial costs. For these reasons, some miners view formalization as another tax. In the appendix, we discuss the role of cooperatives and miners' perceptions of them (see Figure 7).

[49] We focus on perceptions because few households report victimization, leaving little scope to detect reductions on that dimension. Enumerators asked households and individuals whether a member of their household or they were a victim of violence over the last year. If yes, then the enumerator asked if this violence was sexual in nature. This survey flow resulted in few respondents being specifically asked about sexual violence. Moreover, respondents may under-report victimization, due to concerns about privacy, retaliation, or trauma. Enumerators were instructed to privately interview respondents.

In our household survey, we also find that child labor in mining is uncommon: 9% of respondents in DDP clusters report that a child in their household (under the age of 16) worked in or supported a mine in the last year. Enumerators recorded a higher rate of child labor in the mine-site surveys, observing a child at 33% of mines in DDP clusters.[50] We see no indication in either the household or mine-site surveys that DDP is associated with a statistically significantly reduction in child labor. While pervasive in this context, child labor is difficult to measure: site inspections, for example, can result in undercounts if managers anticipate audits or can otherwise limit detection; informants' reports are noisy and can be inflated if, for example, informants believe that reporting child labor might result in additional community benefits, such as educational programs. The mine-site surveys we employ rely on informants' reports and enumerator observation; we expect biases are likely present at both DDP and non-DDP sites.

[50] The reported prevalence of child labor can differ between establishment (i.e., mine-site) and household surveys. For instance, this, suppose that exactly one child works at every mine: 100% of mines would have some child labor, but only 104 children would be employed, which would constitute a small share of households.

Table 7: Conditions of Extraction

Variable	Control	DDP Impact	SE	p	N	Clusters
Forced labor in mining						
Forced to work in a mine (h)	0.00	0.01	(0.01)	0.12	738	43
Forced to work in a mine (i)	0.00	0.00	(0)	0.99	704	43
Forced labor in mine site (m)	0.00	0.01	(0.01)	0.19	58	43
Child labor in mining						
Children (under the age of 15) working in mine (h)	0.05	0.04	(0.03)	0.19	738	43
Child workers in mine site (m)	0.37	-0.04	(0.16)	0.8	58	43
Injuries and accidents related to mining						
Number of accidents involving respondent at the mine (i)	0.05	0.03	(0.03)	0.38	704	43
Respondent involved in a fatal accident at the mine (i)	0.00	0.00	(0.01)	0.6	704	43
Injuries due to accidents at the mine (m)	9.76	-2.62	(5.23)	0.62	58	43
Any fatal accident at the mine (m)	0.00	0.01	(0.01)	0.34	58	43

Note: (m) Mine Site Survey; (h) Household Survey; (i) Individual Survey

Finally, although mine safety is not an explicit focus of DDP, we look at whether injuries or fatal accidents at mines fall as a consequence of greater oversight by state mining authorities. Fatal accidents are rare across all mines, and we detect no statistically significant differences in the average number of injuries between control and DDP clusters.[51]

[51] In Table 13, we find that households report experiencing a higher number of mining-related accidents in DDP areas. This could be an artifact of there being more households employed in mining in DDP areas and, thus, more opportunities for accidents to be reported.

7.4 Economic Well-being

While our estimates are imprecise and cannot support strong conclusions, we uncover some evidence that households living in DDP clusters fare better economically. They report spending 34% more on food (in the week prior to the survey) and are 44% more likely to own a cellphone. When we combine measures of assets (e.g., durable goods, home ownership) and consumption into an index, we see 0.37 higher standard deviations in DDP clusters. This difference, while sizable, is not statistically significant ($p = 0.13$) (see Table 15). We note above that DDP could improve livelihoods in mining communities through at least two

channels: (1) by increasing the profitability or the scale of mining, or (2) by reducing the size and volatility of miners' tax payments. First, we find little to suggest that mines in DDP areas are more productive or sell their minerals at higher prices: Table 12 shows that there are no statistically significant differences in the annual production of cassiterite or other secondary minerals; the number of workers employed; or the value (i.e., sale price) of cassiterite.[52] We do not have data on miners' costs, but we have no reason to expect that DDP would depress input costs.

Second, a larger share of households (46%) work in mining in DDP clusters relative to control (29%) (see Table 13). We do not have data on workers' compensation across mining and other sectors. However, households with members employed in the mining sector report greater consumption of food and mobile credit. Higher economic well-being in DDP areas could thus be due to increased employment in higher-paying mining jobs. (Farming is the most common non-mining job in our sample.)

Finally, households in DDP areas reported lower rates of illegitimate taxation by FARDC and higher rates of taxation by state agents than those in non-DDP areas. With our data, we cannot measure whether there is a commensurate difference in total tax payments. Relatedly, an influx of state services in DDP areas (e.g., formalization, training) could improve livelihoods by making mines more productive, but as we note earlier we see no evidence of higher productivity among mines in DDP areas.

[52] To measure production, enumerators ask informants at mine sites to separately estimate weekly production of specific minerals during the wet and dry seasons. To arrive at an annual estimate, these amounts are then scaled by the number of weeks in the wet and dry seasons. These estimates likely contain a fair amount of noise and miners may overstate their productivity; however, we expect such features to be present in both DDP and non-DDP mines.

7.5 Sub-group Analysis

Our individual data permits an exploration of whether DDP has differential impacts across sub-populations. We focus, in particular, on whether DDP affects men and women differently (see Table 16). Across most survey items, differences between DDP and non-DDP areas do not appear to vary by gender. Notably, we continue to find that DDP is not associated with changed perceptions of security, which is true for both men and women.

There are two exceptions where our indicators suggest differential impacts among female respondents. First, differences in female respondents' knowledge of DDP generally and ITSCI specifically are not as high between DDP and non-DDP areas as they are for men. This is not surprising, as women are less likely to work in mining jobs and, thus, interface with DDP in our treated clusters. Second, we ask respondents how they perceive the mining sectors' impacts on their lives and community. DDP is associated with higher perceptions among women of the impact of the sector — specifically, their perceptions of mining's impacts on access to clean water, health, and their lives generally.

8 Conclusion

We detect both meaningful differences in DDP areas, as well as ample room for further improvement.

We find that DDP accompanies progress towards goals articulated in Annex II: reducing interference by the FARDC, and increasing payment of state taxes. While taxation by state agents is higher in DDP areas, households do not report higher demands for irregular payments. That said, informants still report instances of duplicative, excessive, or unlawful taxation by state agents at mine sites covered by DDP.

We received few reports of armed group activity, victimization, or forced labor in our sample, which limits our ability to detect any reductions along these dimensions. Households' perceptions of security are no different in DDP areas. We also detect no significant differences in child labor or the number of injuries due to accidents reported at mine sites covered by DDP.[53] DDP does not eliminate child labor, and we do not find a statistically significant improvement along this important dimension.

[53] Our point estimates imply reductions in DDP areas, but we cannot reject the null hypothesis that DDP has no effect on these outcomes (see Table 7).

Finally, we find some more tentative evidence that households' economic well-being in DDP areas is higher: consumption of food and mobile credit, for example, increase. We cannot pin down the mechanism for this difference, though; it does not appear to be a consequence of greater productivity or higher mineral prices for mines in DDP areas. It could be due to increased employment in mining or, alternatively, to the differences we note above related to the withdrawal of the FARDC and heightened presence of state agents.[54]

[54] Whether this increased interaction with these Congolese state agents actually benefits households or miners is an important topic for future research. Our descriptive analysis raises concerns about whether these agents fulfill their prescribed roles; we note reports of insufficient technical support, unlawful taxation, and illegal exploitation of mine pits by state agents.

By leveraging matched comparisons, our study better isolates the effects of DDP. Previous work on the topic has suffered from confounding due to simultaneous policy changes or omitted variables that generate a spurious relationship between DDP and outcomes of interest. We note, however, a few limitations of our work. First, matching is a second-best strategy: unlike a randomized control trial, matching relies on stronger assumptions about our ability to measure and match on the variables that affect the rollout of DDP. Second, since we do not have a complete listing of 3T mines participating in DDP in eastern DRC, we cannot assess the representativeness of the DDP mines in our matched sample. Finally, with recent scale-up in these provinces, few 3T mining areas remain untouched by DDP. We struggled to locate comparable control mines in advance of data collection in late 2019; we expect that several of our control mines have since enrolled in DDP. Future research would benefit from access to historical data on the rollout of DDP, as well as opportunities to build evaluation into future scale-up efforts.

References

Congo Research Group. *The CNPSC Rebellion: Social Marginalization and State Complicity in South Kivu*. Congo Research Group, New York, 2019.

Jordan de Haan and Sara Geenen. Mining Cooperatives in Eastern DRC The Interplay Between Historical Power Relations and Formal Institutions. *The Extractive Industries and Society*, 3(3):823 – 831, 2016. ISSN 2214-790X. DOI: https://doi.org/10.1016/j.exis.2016.05.003.

Emmanuel Freudenthal. Who Pays the Hidden Price for Congo's Conflict-free Minerals? *The New Humanitarian*, 2017. https://bit.ly/3bU2Xgc.

Sara Geenen and Ben Radley. In the Face of Reform: What Future for ASM in the Eastern DRC? *Futures*, 62:58–66, 01 2013. DOI: 10.1016/j.futures.2013.10.023.

Internal Displacement Monitoring Centre IDMC. Democratic Republic of the Congo: Country Information. 2019.

Institut National de la Statisque INS. *Annuaire Statistique RDC 2017*. INS, Kinshasha, Congo, 2019.

IPIS/Ulula. *Assessing the Impact of Due Diligence Programmes in Eastern DRC: A Baseline Study*. IPIS Report, Antwerp, 2019.

ITSCI. *ITSCI 5-Year Plan: DRC & Rwanda*. ITSCI, 2011.

ITSCI. *ITSCI Joint Industry Traceability and Due Diligence Programme*. ITSCI, 2016.

ITSCI. ITSCI OVERVIEW: Quarter 1 of 2020. Technical report, ITSCI, 2020.

René Lemarchand. *The Dynamics of Violence in Central Africa*. University of Pennsylvania Press, 2009.

Levin Sources. *Comparative Study of Certification and Traceability Systems*. Estelle Levin Ltd, 2015.

Ken Matthysen and Andrés Zaragoza. *'Conflict Minerals' Initiatives in DR Congo: Perceptions of Local Mining Communities*. IPIS Report, Antwerp, 2013.

Ken Matthysen, Steven Spittaels, and Peer Schouten. *Mapping Artisanal Mining Areas and Mineral Supply Chains in Eastern DR Congo: Impact of Armed Groups & Responsible Sourcing*. IPIS Report, Antwerp, 2019.

OECD. *OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas*. OECD Publishing, Paris, 2016.

Dominic Parker and Bryan Vadheim. Resource Cursed or Policy Cursed? US Regulation of Conflict Minerals and Violence in the Congo. *Journal of the Association of Environmental and Resource Economists*, 4:1–49, 03 2017. DOI: 10.1086/689865.

Dominic Parker, Jeremy Foltz, and David Elsea. Unintended Consequences of Sanctions for Human Rights: Conflict Minerals and Infant Mortality. *The Journal of Law and Economics*, 59:731–774, 11 2016. DOI: 10.1086/691793.

Jason Stearns. *Dancing in the Glory of Monsters: The Collapse of the Congo and the Great War of Africa*. PublicAffairs, New York, 2012.

Nik Stoop, Marijke Verpoorten, and Peter Van der Windt. More Legislation, More Violence? The Impact of Dodd-Frank in the DRC. *PLoS ONE*, 13:1–19, 08 2018. DOI: 10.1371/journal.pone.0201783.

Thomas Turner. *The Congo Wars: Conflict, Myth and Reality*. Zed Books, London/New York, 2007.

Christoph Vogel, Josaphat Musamba, and Ben Radley. A Miner's Canary in Eastern Congo: Formalisation of Artisanal 3T Mining and Precarious Livelihoods in South Kivu. *The Extractive Industries and Society*, 5:73–80, 09 2017. DOI: 10.1016/j.exis.2017.09.003.

World Bank. *Congo, Democratic Republic of — Growth with Governance in the Mineral Sector Project*. World Bank, Washington, DC, 2010.

9 Appendix

9.1 Additional Contextual Detail

Table 8: Characteristics of Mine Sites

Variable	Maniema	South Kivu	Total
Sites			
Number of Sites	46	58	104
Active Sites	46	54	100
ITSCI Sites	32	41	73
Minerals			
Single Mineral	39	39	78
Cassiterite	46	53	99
Coltan	3	15	18
Wolframite	2	4	6
Gold	4	3	7
Technique			
Open-pit Alluvial	29	37	66
Open-pit Eluvial	38	10	48
Gallery or Shaft	12	24	36
Production Stage			
Preparation	0	9	9
Partial	46	11	57
Full	0	38	38
Status			
Industrial Concession	32	37	69
ZEA	8	5	13
Unknown	0	12	12
None	6	4	10
Mobile Coverage			
On Site	11	23	34
By Walking	27	12	39
No Coverage	8	23	31
Compensation			
Cash	30	5	35
Minerals	3	50	53
Both	13	3	16
Protective Equipment			
Majority Protected	1	10	11
Child Labor			
Any Child Labor	28	2	30

Mine Sites

A mine site is a location of mineral exploration or exploitation. IPIS does not set the boundaries of a specific mine site. Rather, it uses the boundaries recognized by actors on-the-ground: miners, local authorities, estate agents, and other stakeholders identify and give names to separate mine sites based on geographic features and/or who organizes production. IPIS checks that it uses

these same names and features to differentiate mine sites during surveying.

ASM is dynamic. IPIS's approach respects this dynamism and avoids superimposing a rigid delineation of sites that risks subdividing (consolidating) pits/chantiers locally understood to be part of the same (different) site.

Production and Revenue Sharing in Mines

Miners and their managers or pit bosses develop agreements about how to share production or profits from ASM. A manager typically finances the mine, providing equipment (e.g., shovels, picks, compressors, etc.) and food for workers during the construction phase. (Workers are not paid during this stage.) Once a mine starts producing, the manager distributes a share of production (i.e., minerals) to the miners or sells the minerals and distributes a share of the revenues. (Miners may have a preference to be paid in minerals, as they can then conduct negotiations with their preferred dealer.) The manager's share also covers their investment and ongoing costs, as well as payments to cooperatives, customary chiefs, and state agents. Past reports suggest that miners collectively receive 40–60% of production or revenues (de Haan and Geenen, 2016). This share varies over time, depending on the debts owed by miners to managers. (Miners sometimes take loans during the preparation phases, when they are not receiving a production share.)

Monitoring Committees

After the embargo on artisanally mined minerals in 2011, ITSCI (in agreement with the Congolese government) set up monitoring committees in every province, including Maniema and South Kivu. These committees were intended to enforce regulations on traceability and help resolve conflicts at mine sites. In 2013, the committees started managing a fund generated from provincial mineral taxation; each provincial monitoring committee is supposed to coordinate with territorial and local monitoring committees to finance development projects. These development funds were later cancelled by the central government, due to concerns about the misappropriation of funds.

Mining Cooperatives

The 2018 Mining Code requires artisanal miners to join a mining cooperative: only members of cooperatives have the right to access ZEAs. Cooperatives are present at 97 of the mines sites in our sample (see Table 9). Cooperatives should be governed by seven principles stipulated by the 2010 "Organization for the Harmonization of Business Law in Africa Uniform Act on Cooperatives":

1. Voluntary membership and open to all;
2. Democratic member control;
3. Economic participation of members;
4. Autonomy and independence;

5. Education, training and information;
6. Cooperation between cooperative organizations; and
7. Voluntary commitment to the community.

In theory, cooperatives can enhance miners' bargaining power vis-a-vis traders and state agents. However, some perceive cooperatives in the in eastern DRC to be instruments that elites use to exert control over miners (de Haan and Geenen, 2016). Figure 7 shows that miners perceive these organizations to be tools of elites or taxation at over a quarter of the mines with active cooperatives. Miners report support in negotiating for a larger share of revenues in only 37% of these mines.

Women also participate in cooperatives and hold a seat on the cooperative's board at 54 of our sampled mine sites (see Table 9).

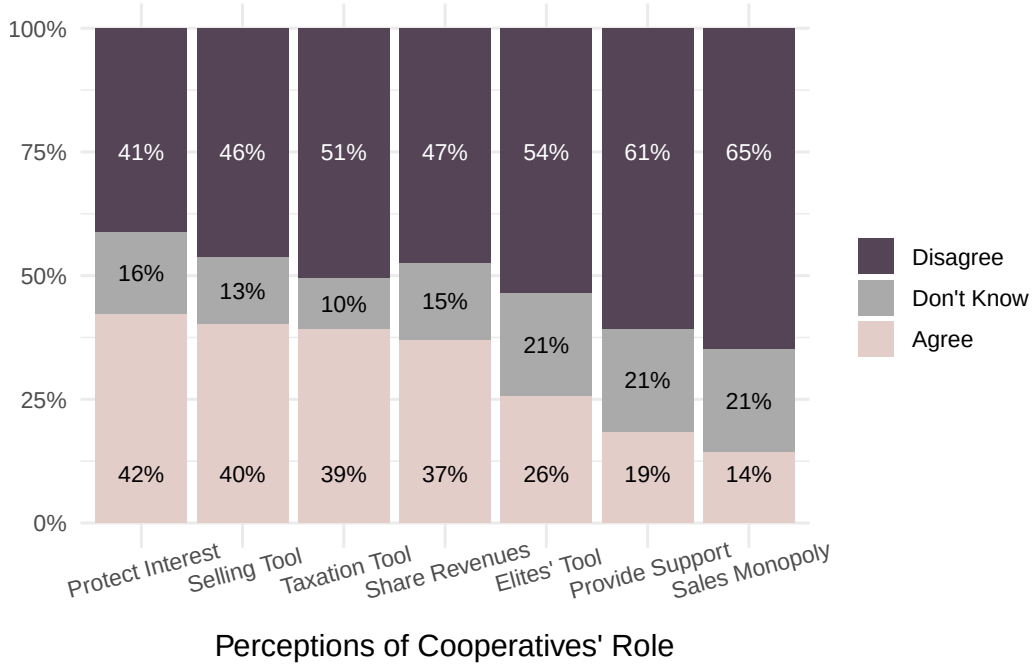

Figure 7: Miners' Perceptions of Cooperatives

Mechanization

We classify mines into three categories based on the tools employed at the site:

1. Low: use of pickaxes, shovels, crowbars, and other hand tools;
2. Moderate: use of any jackhammers, motor pumps, metal detectors, pulleys, mineral washing infrastructure; and
3. High: use of crushers and/or ventilation systems.

In our sample, 68% of mines have a low level of mechanization, 28% have a moderate level and only 4% have a high level of mechanization.

Accessibility of Mine Sites

Only 13 sampled mine sites can be accessed by car or motorbike (see Figure 8). The rest of the sites can only be reached by walking. During the wet season (October–April) , 48% of sites can be reached in less than 2 hours and 43% in more than 2 hours; whereas in the dry season (May–September) 53% of mines can be reached in less than 2 hours, and 38% in more than 2 hours.

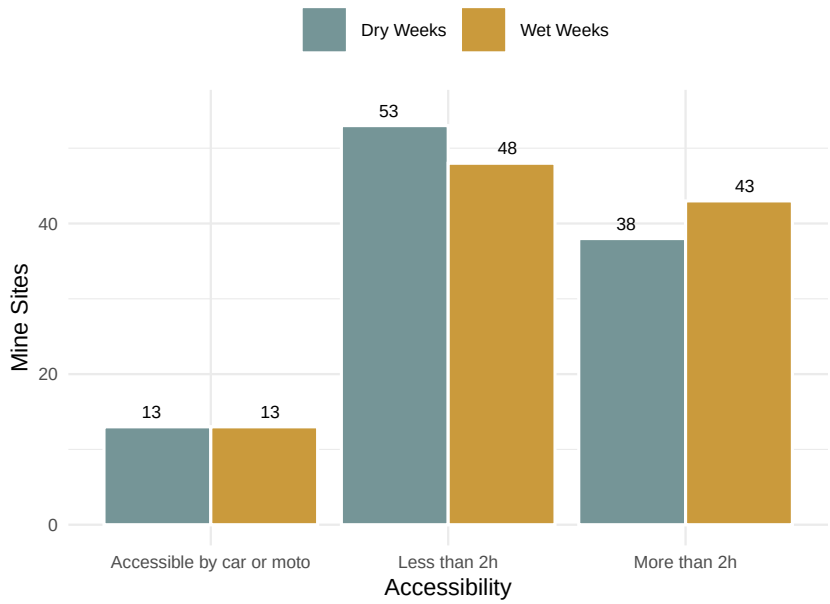

Figure 8: Accessibility of Mines

Mobile phone coverage varies also greatly between mine sites. Phone networks cover 34 sites in our sample; another 39 sites are within walking distance of a phone signal (see Table 8).

Use of Protective Equipment

Miners often work often in unsafe conditions, using only basic protective gear or no protection at all. In only 11 of our sampled mine sites did a majority of miners wear protective equipment (see Table 8). In 47% of the active mines, no protective gear was observed. Miners wear boots in 56% of mines and they use torches and helmets in only 6% and 2% of mines, respectively.

Governance of Mine Sites

Table 9 provides counts of sites in our full sample of 104 where different state or non-state actors are active.

Table 9: Governance of Mine Sites

Variable	Maniema	South Kivu	Total
Status			
Number of Sites	46	58	104
State Presence			
Mining Division	38	43	81
SAEMAPE	44	44	88
Mining Police	11	0	11
State Taxation			
Mining Division	19	36	55
SAEMAPE	37	39	76
State Support			
Support from Mining Div. or SAEMAPE	34	34	68
State Ownership			
State Agents Own Pits	8	2	10
Mining Cooperatives			
Cooperative Present	44	53	97
Male Members	446	1947	2393
Female Members	63	453	516
Female Manager	24	30	54
Documentation			
Any Miner with Official Documentation	13	42	55
Civil Society			
CSO Present	4	9	13
Armed Actors			
FARDC	11	10	21
FARDC Taxation	9	5	14
Raia Mutumboki	0	5	5

Correlates of Household Heads' Perceptions of Security

Figure 9 explores whether negative perceptions of ASM's impacts on public safety relate to experiences with violence. We find that households with negative perceptions are more likely to also report non-state armed groups (NSAG) in or attacking their village, collecting tax, or clashing with the FARDC.

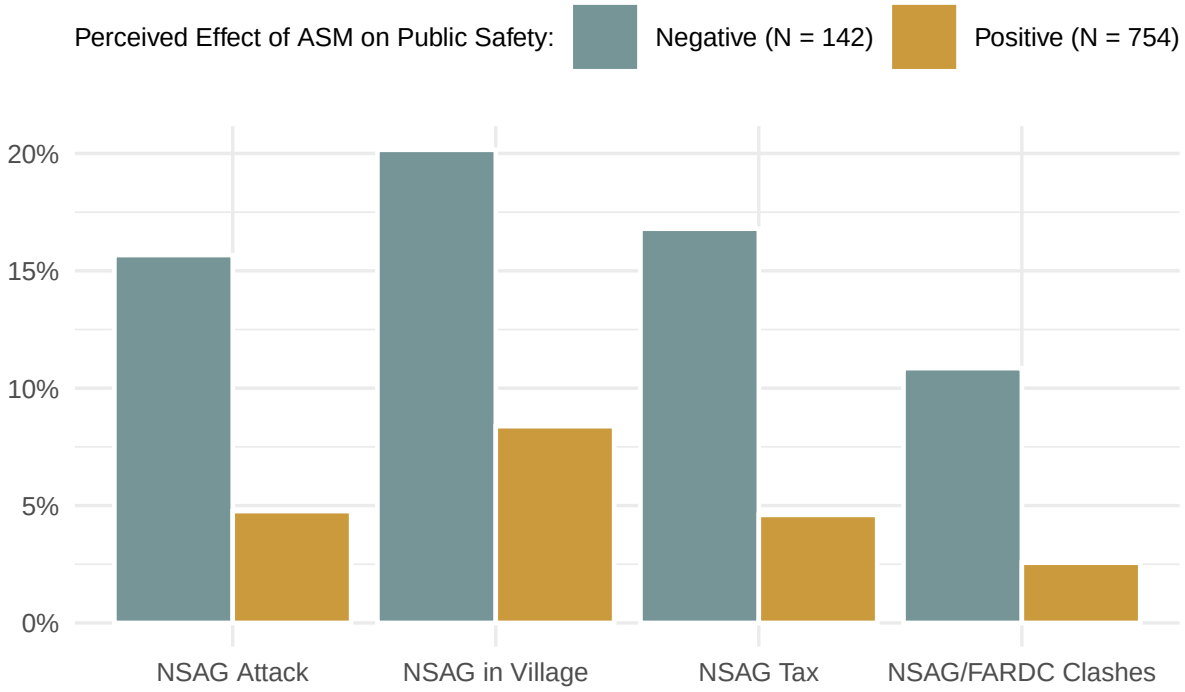

Figure 9: Correlates to Insecurity

Adults' Perceptions of ASM

59% of adults believe that ASM has a positive impact on their their villages. Only 15% disagreed with the statement, while 26% expressed indifference. As is apparent in Figure 10, a majority of adults regard ASM's impact as positive with respect to safety, cohesion ("relations between people"), the economy, and food prices. We see greater concern about ASM's impacts on the environment and public health, though in no domain do even a plurality hold negative perceptions of the sector's impact.

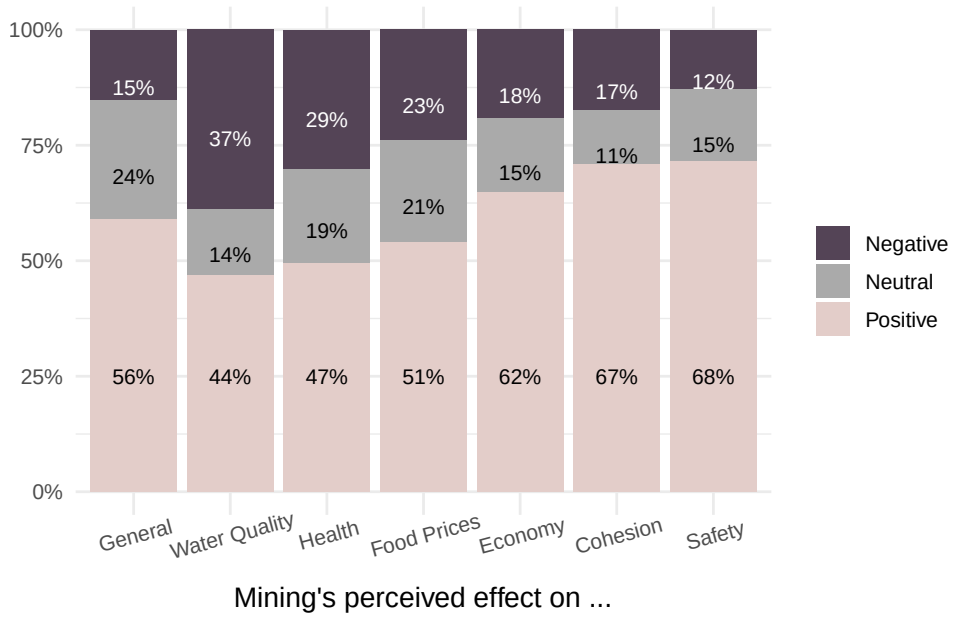

Figure 10: Perceptions of Adults

9.2 Imbalance in Full Sample of 3T Mines

Table 10: Initial Imbalance (N =184)

	Control	DDP	Difference	p
Conflict				
ACLED Deaths: 2007	0.00	0.00	0.00	1
ACLED Deaths: 2008	0.00	0.00	0.00	1
ACLED Deaths: 2009	0.00	0.03	0.03	0.33
ACLED Deaths: 2010	0.00	0.00	0.00	1
ACLED Deaths: 2011	0.00	0.00	0.00	1
ACLED: 2007	0.00	0.01	0.01	0.33
ACLED: 2008	0.00	0.03	0.03	0.33
ACLED: 2009	0.01	0.01	0.00	0.96
ACLED: 2010	0.00	0.00	0.00	1
ACLED: 2011	0.00	0.03	0.03	0.07*
Development				
All Roads	0.59	0.65	0.07	0.72
Motorable Roads	0.35	0.49	0.14	0.39
Nightlights: 2007	0.00	0.17	0.17	0.21
Nightlights: 2008	0.00	0.15	0.15	0.29
Nightlights: 2009	0.00	0.18	0.18	0.16
Nightlights: 2010	0.00	0.39	0.39	0.21
Nightlights: 2011	0.01	0.21	0.20	0.34
Pop. in 2010	750.05	2143.77	1393.72	0.31
Geography				
Dist. Provincial Capital (km)	133.65	115.38	-18.27	0.05*
Elevation (m)	1015.80	919.36	-96.44	0.22
Numbers of Rivers	1.11	0.99	-0.13	0.51
Slope	4.30	4.07	-0.23	0.59
Mining				
Number of 3T Mines	1.51	2.26	0.76	0**
Cassiterite	0.71	0.91	0.20	0**
Coltan	0.17	0.11	-0.06	0.21
Province				
Maniema	0.42	0.62	0.19	0.01**
South Kivu	0.58	0.38	-0.19	0.01**
Territory				
Kabare	0.01	0.00	-0.01	0.5
Mwenga	0.15	0.04	-0.11	0.01**
Pangi	0.13	0.32	0.19	0**
Punia	0.11	0.18	0.07	0.16
Shabunda	0.27	0.12	-0.15	0.01**
Walungu	0.09	0.04	-0.05	0.15

9.3 Balance in Matched Sample

Table 11: Balance after Matching (N =43)

	Control	DDP	Difference	p	Used in Matching
Conflict					
ACLED Deaths: 2007	0.00	0.00	0.00	1	1
ACLED Deaths: 2008	0.00	0.00	0.00	1	1
ACLED Deaths: 2009	0.00	0.00	0.00	1	1
ACLED Deaths: 2010	0.00	0.00	0.00	1	1
ACLED Deaths: 2011	0.00	0.00	0.00	1	1
ACLED: 2007	0.00	0.00	0.00	1	1
ACLED: 2008	0.00	0.00	0.00	1	1
ACLED: 2009	0.00	0.00	0.00	1	1
ACLED: 2010	0.00	0.00	0.00	1	1
ACLED: 2011	0.00	0.00	0.00	1	1
Development					
All Roads	0.53	0.19	-0.34	0.14	0
Motorable Roads	0.27	0.07	-0.20	0.33	1
Nightlights: 2007	0.00	0.00	0.00	1	1
Nightlights: 2008	0.00	0.00	0.00	1	1
Nightlights: 2009	0.00	0.00	0.00	1	1
Nightlights: 2010	0.00	0.00	0.00	1	1
Nightlights: 2011	0.00	0.00	0.00	1	1
Pop. in 2010	247.63	244.55	-3.08	0.94	1
Geography					
Dist. Provincial Capital (km)	135.36	127.88	-7.48	0.59	0
Elevation (m)	774.65	715.94	-58.72	0.46	1
Number of Rivers	1.00	0.81	-0.19	0.59	0
Slope	3.33	3.24	-0.09	0.9	1
Mining					
Number of 3T Mines	1.20	1.39	0.19	0.47	1
Cassiterite	1.00	1.00	0.00		1
Coltan	0.00	0.00	0.00		1
Province					
Maniema	0.67	0.67	0.00		1
South Kivu	0.33	0.33	0.00		1
Territory					
Kabare	0.00	0.00	0.00	1	0
Mwenga	0.13	0.10	-0.03	0.75	0
Pangi	0.40	0.49	0.09	0.57	0
Punia	0.27	0.17	-0.09	0.48	0
Shabunda	0.20	0.23	0.03	0.81	0
Walungu	0.00	0.00	0.00	1	0

Note: p-value omitted for variables used in exact matching.

9.4 Full Item-Level Results

Table 12: Matched Analysis of Mine-site Variables

Variable	Control Mean	DDP Impact	Std. Error	p	N	Clusters
Injuries and accidents related to mining						
Number of injuries due to accidents at the mine	9.76	-2.62	(5.233)	0.624	58	43
Any fatal accident at the mine	0.00	0.01	(0.006)	0.341	58	43
Conflict						
Conflict in the mine site, related to operations	0.18	-0.01	(0.118)	0.917	58	43
Due diligence						
SAEMAPE or Mining Division received training on traceability	0.34	0.45	(0.128)	0.003**	58	43
At least monthly visits from ITSCI	0.00	0.43	(0.104)	0.001**	58	43
Forced labor in mining						
Child workers in mine site	0.37	-0.04	(0.156)	0.802	58	43
Forced labor in mine site	0.00	0.01	(0.009)	0.192	58	43
Insecurity						
Violence reported in the mine site	0.09	-0.05	(0.07)	0.524	58	43
Sexual violence reported in the mine site	0.00	0.00	(0)	1	58	43
Irregular payment to state agents						
Evidence of a form of illegal state taxation	0.65	0.00	(0.156)	0.999	58	43
Labor Demand						
Number of mine workers involved in production	115.09	0.70	(43.696)	0.987	58	43
Number of female workers involved in production	21.13	3.58	(11.448)	0.759	58	43
Production						
Estimate of yearly production for Cassiterite (kg)	26377.98	-1289.96	(11599.002)	0.913	58	43
Estimate of yearly production for Wolframite (kg)	461.63	-417.07	(418.383)	0.335	58	43
Estimate of yearly production for Gold (g)	230.05	-230.05	(161.012)	0.174	58	43
Estimate of yearly production for Coltan (kg)	1716.78	-1568.86	(994.123)	0.136	58	43
Value of Cassiterite per kg (USD)	5.56	-0.62	(0.833)	0.465	58	43
Number of buyers on the sites	4.15	-0.50	(1.378)	0.723	58	43
At least monthly visits by mineral buyers	0.66	0.02	(0.123)	0.855	58	43
State agents in the mines						
Identified a state agent in mine site (last 6 mos.)	0.91	0.05	(0.096)	0.587	58	43
Identified SAEMAPE in mine site (last 6 mos.)	0.86	0.10	(0.104)	0.36	58	43
At least monthly visits by SAEMAPE (last 6 mos.)	0.31	0.31	(0.123)	0.024**	58	43
Identified Mining Division in mine site (last 6 mos.)	0.77	0.08	(0.101)	0.421	58	43
At least monthly visits by Mining Division (last 6 mos.)	0.22	0.26	(0.127)	0.059*	58	43
Taxes: Armed groups						
Identified Armed Groups (Raia) in mine site (last 6 mos.)	0.01	0.00	(0.004)	0.451	58	43
At least monthly visits by Armed Groups (Raia) (last 6 mos.)	0.00	0.01	(0.006)	0.341	58	43
Armed Groups (Raia) requesting taxes in mine site (last 6 mos.)	0.01	0.00	(0.004)	0.451	58	43
Taxes: FARDC						
Identified FARDC in mine site (last 6 mos.)	0.48	-0.28	(0.108)	0.022**	58	43
At least monthly visits by FARDC (last 6 mos.)	0.26	-0.20	(0.119)	0.112	58	43
FARDC requesting taxes in mine site (last 6 mos.)	0.39	-0.25	(0.129)	0.069*	58	43
Taxes: State agents						
Identified a state agent in mine site (last 6 mos.)	0.91	-0.19	(0.166)	0.265	58	43

Table 13: Matched Analysis of Household Survey Variables

Variable	Control Mean	DDP Impact	Std. Error	p	N	Clusters
Due diligence						
Heard of due diligence programs	0.25	0.32	(0.087)	0.002**	738	43
Mentions ITCSI's due diligence program	0.06	0.19	(0.074)	0.019**	650	43
Tagging mineral bags	0.26	0.41	(0.085)	0**	624	43
Tagging occurred 3 or less months ago	0.19	0.37	(0.083)	0.001**	624	43
State presence and services						
Identified a state agent in village	0.44	0.28	(0.073)	0.002**	738	43
At least monthly visits from state agents in village	0.24	0.22	(0.066)	0.004**	738	43
State agent delivered a service in village	0.29	0.31	(0.083)	0.002**	738	43
Identified a state agent in mines near village	0.45	0.28	(0.069)	0.001**	738	43
At least monthly visits from state agents at mines near village	0.23	0.23	(0.074)	0.007**	738	43
State agent delivered a service in mines near village	0.35	0.30	(0.07)	0.001**	738	43
Taxes: State Agents						
State agent collecting taxes in village	0.20	0.19	(0.077)	0.025**	676	43
State agent collecting taxes in mine	0.33	0.19	(0.068)	0.014**	660	43
Irregular payment to state agent						
Irregular payments on behalf of SAEMAPE	0.04	0.04	(0.033)	0.2	724	43
Irregular payments on behalf of Mining Division	0.03	0.03	(0.042)	0.53	729	43
Irregular payments on behalf of Chef Coutumier	0.04	0.01	(0.033)	0.694	730	43
Interference from FARDC						
Identified FARDC members in village	0.66	-0.18	(0.09)	0.067*	698	43
FARDC collecting taxes in village	0.11	-0.03	(0.031)	0.371	674	43
Heard of FARDC collecting taxes in mines near village	0.26	-0.10	(0.084)	0.23	738	43
Heard of FARDC collecting taxes in road near village	0.22	-0.13	(0.076)	0.102	738	43
Interference from armed groups						
Armed group requested tax from household	0.04	0.01	(0.025)	0.537	695	43
Armed group collecting taxes in village	0.01	0.01	(0.011)	0.482	682	43
Heard of armed group collecting taxes in mines near village	0.03	0.00	(0.022)	0.936	738	43
Heard of armed group collecting taxes in roads near village	0.02	0.03	(0.019)	0.117	738	43
Armed group violence						
Violence between armed groups and FARDC	0.03	-0.01	(0.015)	0.363	681	43
Attacks or robbery from armed groups on village	0.01	0.05	(0.036)	0.193	693	43
Number of attacks or robbery from armed groups on village	0.02	0.17	(0.106)	0.127	693	43
Death resulting from attacks from armed groups on village	0.01	0.00	(0.01)	0.878	693	43
Insecurity						
Victim of violence	0.03	-0.01	(0.014)	0.304	738	43
Victim of sexual violence	0.00	0.00	(0.009)	0.669	738	43
Death resulting from violence	0.00	0.00	(0)	0.401	738	43
Violence reporting	0.03	-0.01	(0.014)	0.304	738	43
Perception of safety	2.30	-0.22	(0.137)	0.137	738	43
Perceived effect of mining on safety and security	2.30	0.07	(0.111)	0.529	738	43
Economic well-being						
Access to electricity	0.40	0.10	(0.091)	0.303	738	43
Access to radio	0.42	0.03	(0.053)	0.573	738	43
Access to television	0.09	0.09	(0.06)	0.172	738	43
Household head owns a cellphone	0.34	0.15	(0.057)	0.016**	738	43
Drinking water source	2.61	-0.15	(0.203)	0.476	738	43
Construction materials of exterior walls	2.70	0.22	(0.308)	0.495	738	43
Primary materials of floor	1.24	0.06	(0.159)	0.729	738	43
Fuel for cooking	1.03	0.01	(0.02)	0.664	738	43
Primary material of roof	2.67	0.40	(0.313)	0.223	738	43
Household owns a house	0.93	-0.07	(0.037)	0.076*	738	43
Spending on food (FC)	21625.79	7370.10	(5724.448)	0.217	738	43
Spending on mobile credit (FC)	1908.34	1415.74	(807.442)	0.099*	738	43
Conditions of extraction						

Children (under the age of 15) working in mine	0.05	0.04	(0.032)	0.195	738	43
Forced to work in a mine	0.00	0.01	(0.007)	0.119	738	43
Employment in mining						
Employed	0.95	0.01	(0.025)	0.777	738	43
Primary source of income is mining	0.29	0.17	(0.058)	0.01**	738	43
Accidents related to mining						
Household member involved in accident at the mine	0.06	0.04	(0.027)	0.186	738	43
Number of accidents involving household member at the mine	0.07	0.11	(0.057)	0.074*	738	43
Household member involved in a fatal accident at the mine	0.01	0.00	(0.008)	0.982	738	43
Mining perceptions						
Perceived effect on jobs and businesses	3.53	0.10	(0.114)	0.409	738	43
Perceived effect on safety and security	3.70	-0.07	(0.111)	0.529	738	43
Perceived effect on health	3.27	0.09	(0.127)	0.478	738	43
Perceived effect on quality of water	3.09	-0.15	(0.261)	0.571	738	43
Perceived effect on availability and cost of food	3.40	0.20	(0.129)	0.138	738	43
Perceived effect on relations between people	3.56	-0.01	(0.151)	0.964	738	43
General perceived effect on village	3.53	-0.01	(0.113)	0.936	738	43

Note: Perceptions are measured on five-point likert scale. Outcomes related to construction materials, water source, and fuel for cooking are measured on a quality scale, higher values associated with higher quality.

Table 14: Matched Analysis of Individual Survey Variables

Variable	Control Mean	DDP Impact	Std. Error	p	N	Clusters
Due diligence						
Heard of due diligence programs	0.15	0.28	(0.049)	0**	704	43
Mentions ITCSI's due diligence program	0.03	0.11	(0.044)	0.022**	616	43
State presence and services						
Identified a state agent in village	0.41	0.23	(0.077)	0.008**	704	43
At least monthly visits from state agents in village	0.24	0.15	(0.068)	0.045**	704	43
State agent delivered a service in village	0.25	0.30	(0.075)	0.001**	704	43
Identified a state agent in mines near village	0.38	0.21	(0.074)	0.011**	704	43
At least monthly visits from state agents at mines near village	0.20	0.14	(0.06)	0.033**	704	43
State agent delivered a service in mines near village	0.28	0.24	(0.071)	0.003**	704	43
Taxes: State Agents						
State agent collecting taxes in village	0.19	0.12	(0.066)	0.081*	641	43
State agent collecting taxes in mine	0.26	0.12	(0.077)	0.131	622	43
Irregular payment to state agent						
Irregular payments on behalf of SAEMAPE	0.03	0.03	(0.03)	0.309	691	43
Irregular payments on behalf of Mining Division	0.02	0.03	(0.031)	0.337	699	43
Irregular payments on behalf of Chef Coutumier	0.03	0.01	(0.03)	0.686	698	43
Interference from armed groups						
Armed group requested tax from household	0.01	0.01	(0.014)	0.42	631	43
Insecurity						
Victim of violence	0.02	-0.01	(0.013)	0.259	704	43
Victim of sexual violence	0.00	0.00	(0.004)	0.745	704	43
Death resulting from violence	0.00	0.00	(0)	0.407	704	43
Violence reporting	0.02	-0.01	(0.013)	0.245	704	43
Perceived effect of mining on safety and security	2.25	0.09	(0.079)	0.266	704	43
Conditions of extraction						
Forced to work in a mine	0.00	0.00	(0.005)	0.986	704	43
Employment in mining						
Employed	0.92	-0.06	(0.043)	0.168	704	43
Primary source of income is mining	0.24	0.09	(0.057)	0.139	704	43
Accidents related to mining						
Respondent involved in accident at the mine	0.04	0.01	(0.021)	0.525	704	43
Number of accidents involving respondent at the mine	0.05	0.03	(0.032)	0.377	704	43
Respondent involved in a fatal accident at the mine	0.00	0.00	(0.006)	0.598	704	43
Mining perceptions						
Perceived effect on jobs and businesses	3.52	0.13	(0.105)	0.22	704	43
Perceived effect on safety and security	3.75	-0.09	(0.079)	0.266	704	43
Perceived effect on health	3.17	0.20	(0.108)	0.082*	704	43
Perceived effect on quality of water	2.99	0.04	(0.26)	0.886	704	43
Perceived effect on availability and cost of food	3.31	0.22	(0.1)	0.039**	704	43
Perceived effect on relations between people	3.63	-0.01	(0.16)	0.965	704	43
General perceived effect on village	3.54	0.07	(0.098)	0.492	704	43

Note: Perceptions are measured on five-point likert scale.

9.5 Full Index Results

Table 15: Matched Analysis of All Indexes from Household Survey

Index	DDP Impact	SE	p	N	Clusters
Due diligence	1.14	(0.22)	0**	738	43
State presence and services	0.65	(0.15)	0**	738	43
Taxes: State Agents	0.49	(0.16)	0.01**	700	43
Irregular payment to state agent	0.17	(0.19)	0.4	737	43
Interference from FARDC	-0.33	(0.17)	0.08*	738	43
Interference from armed groups	0.16	(0.17)	0.36	738	43
Armed group violence	0.31	(0.26)	0.26	718	43
Insecurity	-0.09	(0.13)	0.48	738	43
Economic well-being	0.37	(0.23)	0.13	738	43
Conditions of extraction	0.25	(0.15)	0.13	738	43
Employment in mining	0.26	(0.11)	0.04**	738	43
Accidents related to mining	0.20	(0.13)	0.15	738	43
Mining perceptions	0.04	(0.17)	0.8	738	43

9.6 Sub-group Analysis

Table 16: Matched Analysis of Individuals Survey Variables by Gender

Variable	DDP x Male	DDP x Female	Difference	Std. Error	N	Clusters
Due diligence						
Heard of due diligence programs	0.28	0.27	-0.01	(0.08)	704	43
Mentions ITCSI's due diligence program	0.16	0.05	-0.11	(0.06)*	616	43
State presence and services						
Identified a state agent in village	0.19	0.28	0.09	(0.09)	704	43
At least monthly visits from state agents in village	0.10	0.19	0.09	(0.09)	704	43
State agent delivered a service in village	0.33	0.27	-0.05	(0.09)	704	43
Identified a state agent in mines near village	0.19	0.24	0.05	(0.09)	704	43
At least monthly visits from state agents at mines near village	0.14	0.14	0.00	(0.1)	704	43
State agent delivered a service in mines near village	0.25	0.24	-0.01	(0.08)	704	43
Taxes: State Agents						
State agent collecting taxes in village	0.14	0.10	-0.04	(0.11)	641	43
State agent collecting taxes in mine	0.15	0.08	-0.08	(0.07)	622	43
Irregular payment to state agent						
Irregular payments on behalf of SAEMAPE	0.06	0.00	-0.07	(0.05)	691	43
Irregular payments on behalf of Mining Division	0.05	0.01	-0.04	(0.05)	699	43
Irregular payments on behalf of Chef Coutumier	0.02	0.01	-0.01	(0.05)	698	43
Interference from armed groups						
Armed group requested tax from household	0.01	0.01	-0.01	(0.01)	631	43
Insecurity						
Victim of violence	-0.02	-0.01	0.02	(0.02)	704	43
Victim of sexual violence	0.00	-0.01	-0.01	(0.01)	704	43
Death resulting from violence	0.00	0.00	0.00	(0)	704	43
Violence reporting	-0.02	-0.01	0.02	(0.02)	704	43
Perceived effect of mining on safety and security	0.14	0.04	-0.10	(0.11)	704	43
Conditions of extraction						
Forced to work in a mine	0.00	0.00	0.00	(0.01)	704	43
Employment in mining						
Employed	-0.05	-0.08	-0.03	(0.05)	704	43
Primary source of income is mining	0.07	0.10	0.03	(0.1)	704	43
Accidents related to mining						
Respondent involved in accident at the mine	0.02	0.00	-0.02	(0.03)	704	43
Number of accidents involving respondent at the mine	0.06	0.00	-0.06	(0.05)	704	43
Respondent involved in a fatal accident at the mine	0.00	0.01	0.01	(0.01)	704	43
Mining perceptions						
Perceived effect on jobs and businesses	0.05	0.22	0.16	(0.16)	704	43
Perceived effect on safety and security	-0.14	-0.04	0.10	(0.11)	704	43
Perceived effect on health	0.09	0.32	0.22	(0.17)	704	43
Perceived effect on quality of water	-0.12	0.21	0.34	(0.16)*	704	43
Perceived effect on availability and cost of food	0.15	0.31	0.16	(0.15)	704	43
Perceived effect on relations between people	-0.06	0.05	0.12	(0.14)	704	43
General perceived effect on village	-0.06	0.20	0.26	(0.12)*	704	43

Note: Perceptions are measured on five-point likert scale.