**Unintended Consequences of Sanctions for Human Rights:**

**Conflict Minerals and Infant Mortality**

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***Abstract***: Are victims of human rights abuses better off with or without economic sanctions targeted at their perpetrators? We study this question in the context of a U.S. human rights policy, Section 1502 of the 2010 Dodd Frank Act. By discouraging companies from sourcing 'conflict minerals' from the eastern Democratic Republic of the Congo, the policy has acted as a *de facto* boycott on mineral purchases that may finance warlords and armed militias. We estimate the policy's impact on mortality outcomes of children born prior to 2013 and find that it increased the probability of infant deaths in villages near the regulated 'conflict mineral' deposits by at least 143 percent. We find suggestive evidence that the legislation-induced boycott did so by stunting mother consumption of infant health care goods and services.

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## 1. Introduction

To discourage human rights abuses across the world, the United States and other developed countries often turn to a powerful foreign policy tool: economic sanctions. Sanctions against human rights abusers seek to help victims by withholding economic transactions from perpetrators until abuses cease, or other conditions are met (see Hufbauer et al. 2009, Hafner-Burton and Tsutsui 2005). Sanction programs for this purpose may target political regimes of countries (e.g., Iran, Cuba, Sudan), certain companies, individuals such as war criminals, or specific markets such as “blood diamonds.”[1] But sanctions are blunt tools and their widespread use raises questions about their consequences for the populations they are supposed to help. Is it possible to withold market transactions from perpetrators without impairing economic and health outcomes for victims? Are human rights victims better off with or without the sanctions?

Research points to cases in which economic sanctions have ostensibly harmed victim populations. For example, evidence shows that child health degraded after U.S. sanctions on Iraq (Zaidi and Fawzi 1995), Haiti (Gibbons and Garfield 1999), Cuba (Barry 2000), and other countries (Peksen 2011). But did the sanctions *cause* impaired health? It is difficult to know because the sanctions were country-wide and hence the researchers had little choice but to rely on coarse time series and cross-sectional comparisons. Most of the current literature lacks a convincing counterfactual for how child health outcomes would have evolved in the absence of sanctions.[2]

In this paper, we assess the causal impact of economic sanctions targeted toward human rights violators on child health by exploiting what we believe to be an excellent quasi-experimental setting. Our study focuses on a recent U.S. human rights policy, Section 1502 of the 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act. This policy discourages major electronics manufacturing companies - such as Apple, Motorola, and Hewlett Packard[3] - from sourcing ‘conflict minerals’ from the eastern Democratic Republic

[1] In 2016 the US Treasury reports 28 different operational sanction programs naming 21 different countries and over 6,000 people, as well as constraining the operation of markets and trade in diamonds, gold, uranium and other nuclear materials, as well as the conflict mineral markets considered here (US Treasury, 2016). For perspectives on blood diamonds and their governance, see (Haufler 2009) and Olsson (2007).

[2] Using cross-national data, Allen and Lektzian (2012) report evidence that sanctions have negatively affected health outcomes such as immunization rates in targeted countries.

[3] According to Bayer (2015) more than 1,200 different US companies have had to file their compliance with this policy to the Securities and Exchange Commission including both technology firms such as Intel and Xerox as well as media companies such as Walt Disney and apparel manufacturers such as Abercrombie and Fitch. Based on Bayer’s numbers from 2014, the total compliance costs to those firms by 2016 is likely to have approached $1 billion. Bayer (2015) also reports survey evidence that companies’ most frequent reservation about the law was that it rendered them “less competitive due to heavy compliance cost burden[s]”.

of the Congo (DRC).[4] The policy resembles a targeted trade sanction because the goal is to cut off revenue to warlords who control aspects of mineral trade and sometimes commit brutal acts of violence against civilians, including women and children.[5] Section 1502 acted as an "intended or unintended boycott" on purchases of tin, tantalum, and tungsten – the "3Ts" - from the broadly demarcated conflict mineral zone of the eastern DRC (Pöyhönen et. al 2010, 27).[6]

While it is generally accepted that Dodd Frank caused significant declines in 3T mining, it is less clear whether or not "Obama's Law", as it is known in local vernacular, has benefitted Congolese citizens. Decreases in mineral production were absorbed by an artisanal mining sector that had supported an estimated 785,000 miners prior to Dodd Frank (D'Souza 2007) with spillovers from their economic activity thought to affect millions. This is why some observers raise concerns that the conflict minerals legislation might have impaired economic conditions for marginalized populations in areas where mining has slowed (Aronson 2011, Sematumba 2011, Pöyhönen et. al. 2010, Geenan 2012, Seay 2012).

We investigate these concerns quantitatively, by studying the potentially lasting impacts of Dodd Frank through its effects on infant mortality. This is an outcome that could conceivably benefit from Dodd Frank through two channels. First, if the legislation succeeded in achieving its goal of lowering civilian exposure to violent conflict, then child health would presumably improve. Second, if pollution flows from mining impairs child health in nearby villages, then Dodd Frank could have lowered mortality rates through its reduction in mining activity.

Qualitative reports from health NGOs and research from the eastern DRC, however, suggest Dodd Frank could have increased mortality through three channels. First, the law may have reduced income streams to families and communities previously dependent on artisanal mining. Second, the law may have disrupted public health provision and reduced mother access to health care facilities and services. Third, contrary to the policy's purpose,

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[4] The DRC is the world's 11th largest country by area and the 19th most populated. It ranks in the bottom five countries in the world in child mortality rates, and dead last in GDP per capita.

[5] The purpose of Section 1502, in the words of the co-sponsoring Congressman Barney Frank, is to "cut off funding to people who kill people" (Aronson 2011).

[6] Two years after Dodd-Frank was passed, advocacy groups were claiming success, stating "the passage of conflict minerals legislation … [has] helped lead to a 65% drop in armed groups' profits from trade in tin, tantalum, and tungsten …" (Johnson 2013, p. 53). A report by Bafilemba et al. (2014, 2) also points to success, pointing out, for example, that "Armed groups and the Congolese army are no longer present at two-thirds (67 percent) of tin, tantalum and tungsten mines surveyed…"

Dodd Frank apparently increased armed conflict during our time period of study, which could have adverse effects on infant mortality (see Parker and Vadheim 2017).

We test for mortality effects from the Dodd Frank policy using a data set constructed from three publicly available sources. To measure infant mortality, we employ Demographic and Health Surveys (DHS) data from the most recent 2013 survey wave. The data include geo-coordinates of villages along with detailed information about mother respondents. We construct under-1 infant mortality rates based on recall questions, asked of mothers, to measure if and when children died between 2007 and 2013. To identify village locations most directly exposed to Dodd Frank 'treatment' we use International Peace Information Services (IPIS) data on the geo-coordinates of artisanal mining during 2009 and 2010, before Dodd Frank. To identify the location and timing of armed conflict we use the Armed Conflict Location Events Database (ACLED).

Our econometric strategy for isolating the effects of Dodd Frank is based on triple difference comparisons of mortality in 'treated' villages with mortality in two types of comparison villages. The infants in treated villages are in the broadly demarcated policy zone targeted by the boycott, and also near (<20km) a 3T mine that was operating prior to Dodd Frank.[7] One comparison group consists of infants in villages near 3T deposits located outside of the targeted zone. The other comparison group consists of children born in villages within the targeted zone, but far (>20km) from a 3T mine. Infant mortality in the treated and comparison villages were following similar trends prior to Dodd Frank; this supports their validity as counterfactuals for how mortality would have changed absent the conflict mineral policies.

The evidence suggests that Dodd Frank increased the probability of infant deaths for children who live part of or all of their first-year in treated villages under the Dodd Frank regime. Our most conservative estimate is that the legislation increased under-one mortality from a baseline mean of 60 deaths per 1000 births to 146 deaths per 1000 births, which represents a 143 percent increase. While one might be willing to accept higher infant mortality as a necessary cost of defunding illicit armed militias, we also find evidence that mortality rose in policy zone villages near 3T mines that were not controlled by armed groups prior to Dodd Frank. By contrast, we find no evidence that Dodd-Frank affected mortality in villages near gold mines, which are artisanal mines similar in location and scale but that were *de facto* exempt from the Dodd Frank-induced boycott as explained in section 2.

[7] This distance threshold complies with recent literature on the spatial extent of mining impacts (see section 3), but we also employ different thresholds in robustness checks.

We then investigate some of the channels through which Dodd Frank might have caused mortality rates to rise near targeted 3T mines and find suggestive evidence that the legislation did so by reducing consumption of health care goods such as disease-preventing bednets. In contrast, infant mortality decreased, and health care consumption increased, in villages near 3T mines outside of the Dodd Frank-targeted conflict mineral zone. This provides evidence that 3T mineral endowments – which experienced rising world prices during 2010-2012 - may have helped improve infant health in the eastern DRC absent the U.S. human rights policy.

We also investigate the relative impact of armed conflict near (< 20km) villages on infant mortality in order to understand possible benefits if Dodd Frank is eventually successful in reducing violence. The estimates suggest that Dodd Frank would have to cause a large reduction in armed conflict, over a long period of time, in order to offset the 'short-run' increases in mortality rates induced by the legislation through other channels. This is because infant mortality is apparently much more sensitive to factors adversely affected by the policy – such as health care access - than it is to the generalized exposure to armed conflict the policy seeks to discourage.

Our findings provide quantitative backing to qualitative concerns about the human cost of conflict minerals legislation.[8] This work raises questions about the extent to which alternative policies, other than top-down sanctions, could reduce conflict while also improving health outcomes for the same amount of money spent on Dodd Frank lobbying and compliance. Our findings are also relevant to the literature on the natural resource curse, particularly the strand investigating the sub-national effects of mining booms on local communities. Like other sub-national case studies of mining in Africa, South America, and elsewhere, our evidence suggests local mining opportunities are a net benefit for local populations (see section 3). Our setting is unique, however, because policy makers and activists have long assumed that mines in conflict zones such as the eastern DRC were a curse for local civilians, which is why they garnered the label "conflict minerals."

## 2. Background: Mining and Conflict Minerals Legislation[9]

### *A. Artisanal Mining Prior to Dodd Frank*

[8] A growing literature raises skepticism that conflict minerals legislation has helped civilians in the eastern DRC. This literature includes Sematumba (2011), Pöyhönen et. al. (2010), Seay (2012), Geenan (2012), Radley and Vogel (2015), Jameson et al. (2015), and Geenen (2016).
[9] The descriptions in this section draw from Parker and Vadheim (2017).

The DRC contains large deposits of tin, tungsten, and tantalum (the "3Ts") that supply surging world demand for their use in mobile phones and other modern electronic devices. In recent years, armed militia groups have controlled some production of 3T minerals, along with gold, in eastern DRC and they have profited from global demand by taxing and extorting miners. The eastern provinces usually associated with these 'conflict minerals' are North and South Kivu, Maniema, Orientale, and Katanga (Figure 1) (Bawa 2010, D'Souza 2007, de Koning 2011).

The majority of the mines in the eastern DRC are worked by artisanal miners. These miners work independently using their own supplies to pan and dig for alluvial, open pit, and hard rock mineral deposits.[10] Artisanal miners use minimal technology and a labour intensive process. Estimates of the number of artisanal miners in the five eastern provinces are rough but ranged from 710,000 to 860,000 in 2007 (D'Souza 2007). The World Bank (2008, 10) estimates that artisanal miners extracted 90 per cent of the minerals exported from the country in the years prior to Dodd–Frank.

The left panel of Figure 2 shows the locations of artisanal mining sites based on interactive maps created by the International Peace Information Service (IPIS) during 2008-2010, before passage of Dodd–Frank. To construct the map, teams of researchers identified the geographic coordinates of sites and solicited information about mineral resources at those sites. Rather than omitting important mining sites that its researchers could not physically visit, the IPIS estimated those mining locations and included them in the maps. From the IPIS maps, we know that gold and tin mines were most prevalent and tantalum (coltan) and tungsten (wolframite) sites were relatively rare. Approximately one-half of the mines were controlled by, or visited regularly by, armed militias (including the Congolese Army), usually for the purpose of taxing and extorting civilian miners.

### *B. Dodd–Frank Legislation*

The United States' first attempt to regulate conflict minerals was in April 2009 with the proposed Congo Conflict Minerals Act. Congress passed and the President signed a revised version as Section 1502 of the Dodd–Frank Act on July 21, 2010 (Figure 3).[11] Section 1502 is designed to discourage major manufacturing and processing companies from purchasing

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[10] According to the 2002 DRC Mining Code, artisanal mining is 'any activity by means of which a person of Congolese nationality carries out the extraction and concentration of mineral substances using artisanal tools, methods and processes, within an artisanal exploitation area limited in terms of surface'.

[11] See www.opencongress.org/bill/111-s891/show.

conflict minerals. Section 1502 directs the Securities Exchange Commission (SEC) to make disclosure rules for companies manufacturing products containing tin, tungsten, tantalum, or gold (see Woody 2012). The rules require companies to conduct "due diligence" on the origin of minerals; if the origin is from a conflict mining zone, then companies must report on the possibility that warlords have benefited from the purchases. The SEC also authorized Congress to produce a map (which it commissioned from the IPIS) of the conflict mining zone to guide the regulatory process. As we discuss below, 3T mines located within this mapped zone were apparently most directly subjected to intended and unintended boycotts because areas in the mapped zone were explicitly highlighted and visible to SEC regulators.[12]

Although Section 1502 did not prohibit the purchase of minerals from conflict mining zones, many observers say it acted as a swift de facto boycott of 3T minerals (Pöyhönen et al. 2010; Seay 2012). Rather than trying to discriminate mine origin and defend purchases from within the zone as not financing armed militias, many US companies avoided 3T purchases from the entire conflict zone. The boycotting of eastern DRC minerals became more explicit after April 1, 2011, when a coalition of large electronics and high-technology companies – the Electronic Industry Citizenship Coalition (EICC) - stopped buying the 3Ts from smelters unable to prove their source minerals did not fund DRC conflict (Wimmer and Hilgert 2011). This formal boycott was likely a direct response to the Dodd–Frank legislation.

Probably also as a response to Dodd–Frank, the DRC imposed a governmental ban on artisanal mining in September, 2010. The ban covered three provinces - Maniema, North Kivu, and South Kivu (see Figure 2).[13] The DRC governmental ban was lifted in March, 2011, shortly before the international EICC boycott took hold, effectively replacing it (de Koning 2011). We thus see the passage of the Dodd–Frank act in July 2010 as the beginning of a mining disruption and boycott that lasted through 2013, when our study period concludes.

### *C. Impact on mining activity*

[12] The map is at https://hiu.state.gov/Products/DRC_MineralExploitation_2011June14_HIU_U357.pdf.

[13] DRC's President stated the ban's goal was to weed out 'mafia groups' from the mining industry. Some observers think the ban was a response to international pressure to stop trade in conflict minerals (Geenan 2012; Seay 2012). Seay (2012) states: 'Neither Kabilia's ban or the MSC's [EITC boycott] decision to stop buying Congolese minerals would have happened had Dodd-Frank not become law. Both the timing of the actual and de facto bans and all rhetoric surrounding them suggests that these were clear responses to the perceived future effects of the legislation. MSC and other international buyers are not purchasing Congolese minerals due to uncertainty about the SEC regulations on Section 1502'.

How did Dodd–Frank and the associated mining ban and EICC boycott impact mining activity? Official data reveal a large drop in exports of 3Ts during 2011-2012. Figure 4a shows the decrease in tin exported from North Kivu, South Kivu, and Katanga, the tin producing provinces of the DRC. The volume of official exports tracked the world price from 2004-2009, but then dropped significantly during 2010-2011 as the world price continued to rise. Some of the export decrease from the mining zone targeted by Dodd–Frank was offset by increased exports from Katanga Province, which was exempt from the mining ban and largely outside of the conflict territory mapped for the US State Department. We also know that while official exports went to zero during the ban, some 3T mining did continue in the policy targeted zone. A number of Chinese companies continued to buy 3T minerals from eastern Congo but at heavily discounted prices compared to world market valuations (Carisch 2012: 15, see also Johnson 2013).

Export data provide a less reliable indicator of gold production because approximately 98 per cent of gold mined in the eastern DRC was sold through unofficial channels (smuggled), both before and after the Dodd–Frank Act (de Koning 2011; United Nations 2014).[14] Figure 4b shows estimates of gold production over 2004–12. Production generally rose, with a slight decrease during 2011 when the mining ban was in force, but overall there is little evidence that Dodd–Frank reduced gold production.

The indicators just described suggest that Dodd–Frank and the mining ban were effective in slowing 3T mining within the targeted conflict mining zone, but less effective in slowing gold mining. Parker and Vadheim (2017) corroborate these indications by reviewing satellite images of changes in forest cover (from Hansen et al. 2012) around IPIS mining centroids before and after Dodd–Frank. Using deforestation rates as a proxy for the level of mining activity at particular mining sites, they report evidence consistent with the other data on Dodd–Frank's effects on mining activity. Deforestation rates slowed around 3T mine coordinates within the mapped conflict zone after the passage of Dodd–Frank; they did not slow around gold mine coordinates, nor did deforestation rates slow around 3T mine coordinates outside of the mapped zone.

There are two main reasons why gold production rose despite its official status as a 'conflict mineral' under Dodd–Frank. First, DRC gold mainly goes to the Middle East and East Asia to supply jewellery markets, whereas 3Ts are primarily consumed by companies

[14] The United Nations (2014) reports that networks engaged in smuggling gold from the DRC neighboring countries are more than 20 years old, and deeply entrenched. Gold is easier and more profitable to smuggle than the 3Ts because it is much more valuable by weight.

that are members of the EICC or regulated by Dodd–Frank (de Koning 2011). Second, while it is technologically feasible to track the origin of 3Ts and demonstrate whether or not their origin differs from those controlled by armed groups, this is less easily accomplished for gold. This is because gold is more easily smelted (i.e. separated from waste rock) on site or earlier in the supply chain (Lezhnev and Prendergast 2009; Schraeder 2011).

To summarize, we emphasize the following: a) artisanal mining was an important economic sector in the eastern DRC prior to Dodd–Frank; b) artisanal mining was dramatically disrupted by a boycott of purchases that was triggered by Section 1502; and c) there are several pieces of evidence indicating the boycott and certification policy slowed 3T mining within the Dodd–Frank targeted conflict mineral zone, but less or no evidence to suggest that 3T mining slowed outside the zone, or that gold mining slowed inside or outside the zone. In the sections that follow, we discuss and then estimate the impacts of these mining policies on infant mortality in locations near artisanal mining sites.

## 3. Related Literature

The Dodd–Frank sanctions and certification policy could potentially impact child mortality in the eastern DRC via four main channels. These are 1) conflict and violence; 2) family income and employment; 3) access to health care services; and 4) child and mother exposure to mining pollution. To inform our empirical analysis, we briefly describe literatures related to these channels. Prior to describing the literature on these channels, we first provide background on child mortality in Africa.

### *A. Child Mortality in Africa*

A large literature spanning many decades investigates the determinants of child health generally, and infant mortality specifically, in Sub-Saharan Africa. The global infant (under-1) mortality rate in 2012 was 35 per 1,000 live births compared to 63 per 1,000 live births in 1990, an improvement of over 40 per cent in two decades (UNICEF 2013). Although countries in Sub-Saharan Africa still endure high rates of infant mortality, Sub-Saharan Africa as a region has also experienced a drastic decrease in infant mortality rate. The highest rates of infant mortality, however, are still found in Sub-Saharan Africa: at 64 per 1,000 live births (1 in 16), it is more than 12 times the average in developed regions. Furthermore, the high fertility rate in Sub-Saharan Africa implies that by 2050, almost 40 per cent of all births will take place in Sub-Saharan Africa, so the actual worldwide number of infant deaths in this region may actually go up.

As of 2013, the DRC had the sixth highest infant mortality rate in the world, at 78 per 1,000 live births.[15] Following global and African trends in infant mortality, the DRC's national rate has also fallen steadily over time, including during our study period of infants born during 2007–12. Across our study region, infant mortality changed from 87 per 1,000 in 2007 to 55 per 1,000 in 2009 to 72 per 1,000 in 2012. As we describe in more detail below, however, infant mortality rates varied widely across villages in our study region of the eastern DRC (Figure 1).

There is an extensive public health literature indicating that infant mortality is affected by: 1) an infant's gender, birth order, birth interval; 2) parents' education level, age, mother's health, family income, and mother's intrahousehold bargaining power; and 3) household residency, wealth, water sources, and number of children (see e.g. Thomas et al. 1990). Kudamatsu et al. (2012) and Han and Foltz (2015) further demonstrate the importance of climate and weather variables in child mortality outcomes.

### *B. Civil Conflict and Child Health*

The ongoing conflict in the eastern DRC has elements of civil war, terrorism, and gang-related violence (Mampilly 2011; Austesserre 2012; Stearns 2014).[16] Literatures related to our study therefore include those focused on the effects of these types of conflicts on child health. Recent studies of civil war in Burundi (Bundervoet et al. 2009), Nigeria (Akresh, Bhalotra et al. 2012), and Ethiopia (Akresh et al. 2012), report evidence that a mother and child's exposure to conflict early in life causes long-term negative health impacts on surviving children. Recent studies of terrorism in Columbia (Camacho 2008) and Palestine and Israel (Mansour and Rees 2012) find that neonatal (in utero) exposure to terrorism incidents reduce child health, measured by birth weight.[17] With respect to gang violence, a recent study by Koppensteiner and Manacorda (2016) finds that increased incidents of homicides in a mother's neighbourhood led to lower birth weights in Brazil.

There is also a small literature on conflict and infant mortality in the DRC, including a recent working paper by Dagnelie et al. (2015), which focuses on the civil war period of 1997–2004. They study the relationship between armed conflict at the district level (there are

[15] This ranking is based on data accessed at the World Bank's website at http://data.worldbank.org/indicator/SP.DYN.IMRT.IN.
[16] A common but debated assumption is that this violence has been motivated and funded by global demand for the region's mineral endowments (Cuvelier et al. 2014).
[17] Camacho (2008) does not focus on infant mortality but Mansour and Rees (2012) find weak evidence, at best, that infant mortality was directly impacted by a mother's exposure to terrorist attacks. Low birth weights, however, are a predictor of higher rates of infant mortality (Almond et al. 2005).

38 districts in the DRC and 12 in the eastern DRC) and under-1 mortality rates and find evidence that conflict increased under-1 child mortality for females but not for males. Earlier studies also consistently find higher rates of child mortality in conflict areas of Africa using different econometric techniques (Guha-Sapir et al. 2005; Guha-Sapir and D'Aoust 2010).

Based on the literature just cited, and intuitive reasoning, we conclude that Dodd–Frank could reduce infant mortality if it succeeds in lowering mother and infant exposure to conflict. There is evidence, that Dodd–Frank did not reduce conflict during our 2010-2013 study period (Parker and Vadheim 2017).[18] This suggests that any benefit from Dodd-Frank through the conflict channel may have to arise over a longer time period.

### *C. Mining and Child Health*

Dodd–Frank could have also affected child health through its effects on family income and on mother and child exposure to mining pollution. Aggregate macro-level studies generally find that countries dependent on mining have lower growth and lower incomes than others (see van der Ploeg 2011; Deacon 2011; Edwards 2016). These results, however, rarely hold in micro studies, which generally associate mining booms with increases in local incomes (see Aragón et al. 2015 for an overview). At the local level, mining can generate positive income effects through fiscal and employment channels. Fiscal channels, in which there are spending benefits from government mining revenues (see Caselli and Michaels 2013), require strong functioning institutions, which are not present in the eastern DRC, at least not through formal governance. Positive employment effects, in which earning opportunities are generated in the mining industry with spillover benefits to non-tradable sectors (see Aragón and Rud 2013; Loayza et al. 2013; de Haas and Poelhekke 2016), are likely present and important in the eastern DRC.[19]

The literature also provides evidence on the spatial extent of income benefits, and on the differential impact of mining on women, particularly in Africa. De Haas and Poelhekke (2016) and von der Goltz and Barnwal (2014), for example, suggest the effects are

[18] Instead of improving law and order, Parker and Vadheim (2017) explain how the legislation may have broken down a fragile, low-conflict equilibrium in which militia groups were acting as organized criminals and providing a crude form of security at and around mining sites. Their reasoning is informed by other studies of conflict in the DRC, which also explain why valuable mineral endowments can reduce violence in some cases (see Maystadt et al. 2014; Sanchez de la Sierra 2015a, 2015b). More generally, the economics literature on organized criminals highlights their interest in providing order and stability in certain industries and neighborhoods when providing (e.g., Fiorentini and Peltzman 1997; Skaperdas 2001; Buonanno et al. 2015).

[19] The positive benefits of a mining boom could in theory be offset by the crowding out of other local sectors providing tradable goods (e.g. manufacturing, commercial agriculture) but this is unlikely to be a problem in the eastern DRC which produces few tradable goods other than natural resources.

concentrated within a 20km distance from the mine. Tolenen (2014) finds evidence that a gold-mining boom in Ghana improved employment outcomes near the mines while von der Goltz and Barnwal (2014) find significant positive effects on villager asset accumulation near mines in developing countries in general. In a cross-country study using DHS data spanning Africa, Kotsadam and Tolonen (2016) find that mining booms induce men to move into skilled manual labour jobs while women move from agriculture into service industries and become more likely to have yearly rather than seasonal cash incomes. When mines close, men return to agriculture while women are more likely to exit the labour force. The Kotsadam and Tolonen (2016) study implies that mining declines in African countries have the strongest negative effects on women's labour outcomes.

While we expect the positive income effects of mining booms to reduce child mortality, these benefits could potentially be offset by the impacts of mining pollution on child health. Aragón and Rud (2016) find reductions in agricultural productivity in the vicinity of gold mines in Ghana. They attribute the lower productivity to both air pollution reducing labour productivity, as well as pollution of the soil, water, and air that might affect agriculture directly. The effects are strongest within 20km of the mining site, and decline with distance from the mine beyond that threshold. The same pollutants that affect labour productivity could have health effects with potential impacts on child survival.

Research by von der Goltz and Barnwal (2014) on the health effects of mining across 44 countries finds that mining is associated with increases in stunting (i.e. malnutrition) of children, but that those effects are localized within 5 km of the mine, and specifically linked to mining that generates lead pollution. They conclude that while mining communities enjoy substantial increases in wealth, these increases do not protect them from the pollution aspects of mining stemming from lead pollution. Romero and Saavedra (2015), studying gold mining in Colombia, find that newborns with mothers living within 10km of a mine are healthier (higher APGAR scores). They attribute the higher APGAR scores near mines to higher incomes and potentially better water and sewer systems.

Perhaps most relevant for our research is recent work by Chunan-Pole et al. (2015), which focuses on the health and income effects of large gold-mining operations in Ghana. That work shows large decreases in infant mortality at both the local and district level in and around mining operations. They attribute this health benefit to increased access to prenatal care as well as lower incidence levels of diarrhoea among households indigenous to the mining area. They also find robust positive local income effects due to gold mining coming from increased employment opportunities and cash earnings. Tolonen (2014) also finds decreasing child mortality especially for girls in gold-mining areas, likely due to women's better access to market opportunities and health care facilities.

Overall the health and mining literature in Africa suggests that mining, at least when large scale and formal, is likely to improve child health outcomes in the mine-dependent communities through a combination of better access to health infrastructure and higher incomes for their parents, especially their mothers. The closing of a mine is likely to produce significantly worse outcomes for infant children than for other members of the family because women, their primary caregivers, are likely to experience large employment and income shocks.

## 4. Data for Main Empirical Analysis

To test for the effects of Dodd–Frank on child mortality, we create a data set from publicly available sources. In this section we describe the data and key variables.

### *A. Outcome Variable: Infant Mortality*

Data on infant mortality come from the Demographic and Health Survey (DHS) in DRC, of which we only use data from the five eastern Congo provinces. We employ the 'births recode' data set from the 2013–14 survey wave. In this wave, survey teams asked women to recall their complete birth history as well as the dates (month and year) of their children's deaths. The DHS data set also includes information on birth order, child gender, household size, and mother's education and marital status at the time of the interview. The survey teams conducted multiple interviews within each enumeration area (village). The data include geo-coordinates of the enumeration sites, but those geo-coordinates have been randomly altered within a 10 km radius to preserve the anonymity of survey respondents.

To mitigate potential error in mother's recall, we focus on recent history by creating a mortality measure spanning births occurring from 2007 through 2012. We focus on under-1 mortality but the findings are similar with neonatal mortality as illustrated below. Our ability to analyze longer age spans is limited, because we cannot observe the future mortality rate of children still alive at the end of the survey period. For example, we know definitively if a child born in 2012 reached one year of age by the end of 2013, but we do not know whether or not a child born in 2012 will reach five years of age. Each observation $i$, is a child for whom we construct a binary under-1 mortality variable, equal to 1 if the child died before his or her first birthday and 0 otherwise.

Due to the structure of the DHS recall data, the births during 2007–12 are linked spatially to the village of mother's residence when she was interviewed during 2013–14. The data set does not identify whether or not the mother moved from a different village during the period of our analysis, 2007–12. This feature of the recall data is important to consider when interpreting data patterns, as we explain below.

Table 1 summarizes the 'Under-1 mortality' variable and the other relevant DHS variables used in the analysis. For all variables, the unit of analysis is the under-1 child. We observe the additional covariates at the level of the mother, and we observe the coordinates of the enumeration area (village) with random error. The mean of the dependent variable is 0.072, which implies an infant mortality rate of 72 deaths per 1,000 births.

### *B. Treated and Control Village Groups*

We employ a single variable to assign 'treatment' over time and across villages most directly affected by the conflict mining policies (see Figure 2). Although the use of a single indicator variable forgoes details about the timing of different policies (e.g. the passage of Dodd–Frank in July 2010, the mining ban in September 2010, the EICC boycott in April 2011), this simple choice has advantages. Importantly, it is likely inappropriate to consider the policies following up on Dodd–Frank as separate and independent events when the passage of Dodd–Frank likely triggered the subsequent policies as discussed in section 2.

We chose July 2010 as the time in which Dodd–Frank 'treatment' begins, although formal regulatory authority of Section 1502 was not exercised until later. For children born earlier than July 2010 in the affected villages, the 'treatment' variable takes a fractional value ranging from 1/12 to 1 based on the proportion of a child's first year under the Dodd–Frank regime. Our choice to define treatment as beginning in July 2010 is based on the work of researchers who have argued that Dodd–Frank caused a de facto boycott of 3Ts shortly after it was passed, long before the more official boycott began in April 2011 (see e.g. Pöyhönen et al 2010; Seay 2012). In robustness checks, shown below, we demonstrate the main results are similar when we drop 2010 births from the sample.

We define a village as 'treated' if two conditions hold. First, the treated village must have geo-coordinates within the spatial 'policy zone' most explicitly targeted by the conflict mineral policies. The policy zone is the union of space appearing on the US State Department's Dodd–Frank Section 1502 map of conflict mines and the three provinces subject to the mining ban.[20] The second condition is that treated DHS villages must be close in distance to at least one 3T mine operating prior to Dodd–Frank, as identified by the IPIS 2009 and 2010 mining surveys. This second condition assumes that the de facto boycott and the related mining ban have disproportionately affected villages closest to 3T mines.[21]

To operationalize the 'close-in-distance' condition, we choose a distance threshold of 20km, which follows the distance used in the literature on mining impacts (e.g. Aragón and Rud 2015; von der Goltz and Barnwal 2014; de Haas and Poelhekke 2016). In our case, using a shorter distance may be inappropriate, given the random jiggering of up to 10km that is added to DHS enumeration coordinates to preserve the anonymity of respondents. Using a further distance would dilute the potency of the policy treatment and potentially open the regressions up to more unobservable sources of bias. In robustness checks, presented below, we show the main findings are strongest at a distance of 10km, and then diminish with distance up to 50km.

Figure 2 illustrates the 'treatment' designation of all 201 DHS villages in the eastern DRC, with the treated villages depicted by dark circles. Figure 2 also shows the two sets of villages that comprise counterfactual, 'untreated' villages. One counterfactual group of villages—depicted by dark squares—consists of those within 20km of a 3T mine, but outside the policy zone. Another counterfactual group of villages—depicted by light circles—consists of those within the policy zone, but further from 20km to a 3T mine. We employ all village types in our econometric analysis as described below.

We also identify villages within 20km of a gold mine inside the targeted policy zone and separately compare their mortality outcomes before and after Dodd–Frank with the mortality outcomes of villages within 20km of a gold mine. We do not anticipate any Dodd–Frank effect, however, because gold has been de facto exempt from the Dodd–Frank induced boycott as discussed in section 2. Figure 2 shows the spatial distribution of gold mines and Table 1 indicates that 31 percent of the villages were within 20km of at least one gold mine.[22]

[20] This definition of the policy zone is consistent with the Parker and Vadheim's (2017) definition of the area most directly affected by the conflict mineral policies. The US State Department map is available at: https://hiu.state.gov/Products/DRC_MineralExploitation_2011June14_HIU_U357.pdf.

[21] To test for heterogeneity in the effects we also disaggregate our measure by whether the mine near a village was operated by an armed group or not. This provides a measure that is robust to whether the mine is intended to be treated or is treated by the boycott spillover effect.

[22] If we were certain that Dodd–Frank had no effect on gold mining, we could consider the estimates of Dodd–Frank on gold-mining villages in the policy zone as placebo tests of its effects. However, it is likely that Dodd–Frank had at least some impact, albeit small, on gold mining and the DRC's mining ban may have also temporarily disrupted gold mining (see section 2).

*C. Rainfall Seasons and Shocks*

Previous literature suggests that weather seasons and precipitation can affect child health and mortality in underdeveloped countries through increased disease burdens during wet periods (e.g. malaria exposure) and from increased or decreased agricultural production affecting nutrition (see Kudamatsu et al. 2012; Han and Foltz, 2015). To measure abnormal precipitation, we follow Maystadt et al. (2014) by constructing a standardized measure of rainfall for each child in the following way. First, we construct a three-month rolling average of precipitation at each DHS enumeration site using CHIRPS data.[23] Then we take the three-month average before the child's birth, subtract the mean of the three-month averages, and divide by the standard deviation of the three-month averages. This gives a standardized measure of relative rainfall before the child's birth. We employ an equivalent process to construct a standardized measure of rainfall during the three months after the child's birth. The resulting variables, shown in Table 1, have means of zero (by construction) and ranges from -2.54 to 4.50 for after birth and -2.62 to 4.02 for before birth.

To account for the possibility that rainfall seasons are also important determinants of child mortality, we have constructed indicator variables for wet and dry season patterns near each enumeration village. We identify the driest and wettest three months in each territory based on long-run precipitation averages. The 'Wet season' indicator equals one if the child is born in a month for which the long-run average precipitation for that month ranks among the highest three. Similarly, the 'Dry season' indicator is equal to one if the child is born in a month for which the long-run average precipitation for that month ranks among the lowest three. Table 1 shows summary statistics of these measures.

*D. Control Variables*

We also control for factors, observed at the child and mother level that may affect mortality outcomes. At the child level we include an indicator for 'Child gender' and the variable 'Birth order.' 'Birth order' measures the sequencing of the child within the family with a lower number indicating a later (younger) child, as a way of capturing sibling rivalry

[23] We use the Climate Hazard group InfrRed Precipitation with Station (CHIRPS) data archive to map each DHS cluster coordinate with daily and monthly precipitation estimations during the study period. We have selected CHIRPS dataset because it uses both new resources of satellite observations, such as gridded satellite-based estimations from NASA and NOAA, and also in situ precipitation gauge observations from ground stations to build a high resolution ($0.05^0$) estimation model (Funk et al. 2014). Second, we use CRU TS3.10 for daily and monthly average, min/max temperature estimation for $0.5^0$ resolution. CRU TS3.10 updates previous CRU TS3.00 with observations at meteorological stations across the world's land areas up to December 2009. Station anomalies were interpolated into 0.5◦ latitude/longitude grid cells covering the global land surface (excluding Antarctica).

effects found to be important in African countries (see Morduch 2000). ‘Household size’ is measured at time of the interview as is the mother’s years of education and her marital and literacy status.

## 5. Main Empirical Analysis

In this section, we examine the reduced form impact of the conflict mineral policy on infant mortality. We begin with graphical evidence and then present econometric estimates.

### *A. Graphical Evidence*

Figure 5 compares trends in mortality rates for villages within 20km of at least one 3T mining site, with the solid line representing the mortality rate in the ‘treated’ villages depicted by dark circles in Figure 2. The dashed line represents the mortality rate in counterfactual villages within 20km of at least one 3T mine but outside the policy zone, depicted by the dark squares in Figure 2. Comparing the two lines, we see that mean mortality rates in both village groups were following the same parallel trends through 2009, the final year before the conflict mineral policies. Prior to 2010, mean levels of mortality were higher in the counterfactual villages. Beginning in 2010, the situation reversed such that mortality rates were higher in the treated villages, in the aftermath of Dodd–Frank. This figure provides a visual indication that Dodd–Frank and the mining ban caused increases in mortality for treated villages relative to other villages near mines not targeted by the policy.

There are two other features of Figure 5 to highlight. First, a comparison of the dashed line mortality patterns in villages outside of the policy zone with the world price of tin (see Figure 4) suggests a strong, negative correlation between the two during 2007–12. The Pearson correlation coefficient is -0.80. This correlation suggests that infant mortality rates in villages near tin mines would have declined with exogenous increases in the world price, absent the Dodd–Frank induced boycott.[24] This is evidence that mining booms improve infant health. The second feature of Figure 5 is that infant mortality rates were lower in villages near 3T mines inside the policy zone, prior to Dodd–Frank. This may suggest that income benefits and/or living conditions near mines were in fact greater in the conflict mining zone.

Figure 6 compares trends in mortality rates for the treated villages with trends across a different set of counterfactual villages: those within the policy zone, but more than 20km

[24] The world prices of tungsten and tantalum also increased in the post-Dodd–Frank period relative to the pre-Dodd–Frank period. We focus on tin only because the majority of the 3T mines in the IPIS data were tin mines.

from a 3T mine as depicted by the light circles in Figure 2. These counterfactual villages should be subject to the same regional trends in mortality, but differentially impacted by the conflict mineral policies. Comparing the two lines, we see that mean mortality rates in both village groups were following roughly similar trends through 2009. Prior to 2010, mean levels of infant mortality were higher in villages away from the 3T mines, which is consistent with infant mortality rates benefiting from being near an active mine. Beginning in 2010, the situation reversed such that mortality rates became higher in the villages close to a 3T mine. This figure provides visual evidence that conflict mineral policies caused increases in mortality in villages close to 3T mining sites.

### *B. Econometric Model and Sources of Identification*

To implement formal tests, we estimate a linear probability triple difference-in-difference regression model of the causes of infant mortality in eastern DRC. For each child, *i*, born to mother, *m*, in village, *v*, located in territory, *t*, in province, *p*, in month, *k*, during year, *y*, we estimate the probability that the child dies in his/her first year. We estimate mortality as a function of whether the child's birth is in a village that is "treated" by the Dodd Frank policy by being less than 20km from a 3T mine, $3TInd_v$, within the Dodd Frank policy zone, $PolicyZone_v$, after its passage in 2010, $postDF_{yk}$. Because the law also potentially affects gold mines, we also include an indicator for whether there is a gold mine near the village of a child's birth, $GoldInd_v$, which receives the same difference-in-difference treatment as the 3T mining village indicator.

In order to control for potentially confounding effects we include a number of covariates as well as fixed effects. The covariates include mother level variables, $X_m$, which include age, literacy and marital status; child level variables on birth order, $Order_i$ and gender $Male_i$; and two village and month of birth measures of weather and climate denoted by the variable $Rain_{vk}$. In terms of fixed effects we include indicators for birth month, $\omega_k$, to control for possible seasonal patterns in mortality, and use either mother, $\phi_m$, or village level, $\alpha_v$, fixed effects to control for time-invariant mother and location effects.[25] We also include variables in all regressions to capture time dependent effects. Depending on the regression the included time effects are either: year dummies, $\mu_y$, which capture area wide year effects

[25] Due to multicollinearity issues, we are not able to use both mother and village level effects in the same regression. When we use mother level effects, $\alpha_v$, we also drop the mother level controls, $X_m$.

for infants born during 2007-2012; province specific year effects, $\delta_{y\times p}$, to allow time effects to adjust flexibly to regional patterns; or territory specific linear time trends for each of the 70 territories, $\sigma_t y$.[26]

Putting all of those variables and effects into an equation produces equation (1) below:

$$\begin{aligned} & mortality_{imtpyk} = (\alpha_v \ or \ \phi_m) + \omega_k + (\mu_y \ or \ \delta_{y\times p} \ or \ \sigma_t y) + \pi Order_i + \upsilon Male_i + \eta Rain_{vk} + \gamma X_m + \\ (1)\quad & \beta_1(postDF_{yk} \times PolicyZone_v) + \beta_2(postDF_{yk} \times 3TInd_v) + \beta_3(postDF_{yk} \times 3TInd_v \times PolicyZone_v) \\ & + \beta_4(postDF_{yk} \times GoldInd_v) + \beta_5(postDF_{yk} \times GoldInd_v \times PolicyZone_v) + \varepsilon_{imtpyk}. \end{aligned}$$

where *i* = child, *m* = mother, *v* = village, *t*= territory, *p*= province, *y* = year of birth, and *k* = month of birth.

The $\beta$ coefficients are of primary interest, particularly $\beta_3$, which is the triple difference estimate of the policy treatment effect, where $\hat{\beta}_3 > 0$ implies Dodd Frank increased mortality rates in 3T mining villages within the policy zone. The coefficient $\beta_1$ measures the difference in mortality before and after Dodd Frank at a broad and diffuse ‘policy-zone’ geographic level; we expect $\hat{\beta}_1 = 0$ because the policy is unlikely to have had a measurable impact on mortality outside of mining villages. The coefficient $\beta_2$ measures the pre and post-Dodd Frank difference in mortality for all villages within 20km of 3T mines. We have no *a-priori* expectation of the sign of $\hat{\beta}_2$; the graphical evidence described above suggests the high world prices of tin during 2010-2012 decreased infant mortality in 3T mining villages outside of the policy zone, but Dodd Frank likely suppressed the benefits for mining villages inside the policy zone. The coefficient $\beta_3$ measures any additional pre and post-Dodd Frank difference in mortality for the subset of ‘treated’ 3T villages within the policy zone. The coefficient $\beta_5$ represents the policy effects on villages near gold mines within the policy zone. Because these gold mines were effectively exempt from Dodd Frank, we expect $\hat{\beta}_5 = 0$.

The variation used to identify policy effects depends on which set of fixed effects are included. The most demanding specifications include both mother fixed effects and province-specific year effects or territory-specific trends. These specifications, however, rely on rather

[26] We have also estimated a more flexible version of the model, to allow each of the 70 territories to have unique year effects. Although those models generate similar results, we do not present them here because the identification of the policy effects in that model only comes from village-level variation in Dodd Frank treatment in a few territories (see figure 2, right-hand panel).

narrow, within-mother and within province variation in treatment for identification of the key parameter, $\beta_3$. By contrast, the specifications with village fixed effects and only area-wide year effects are less demanding but rely on broader variation in village outcomes – i.e., variation across villages throughout the entire study area - for identification of $\beta_3$. We present the full range of results, but our favored specifications are those with mother fixed effects.

*C. Main Results*

Table 2 shows our main estimates from a linear probability model for under-1 mortality with heteroscedasticity-robust standard errors clustered at the village level. This clustering strategy accounts for possible serial correlation within villages, and for the heteroscedasticity generated by the LPM model (see Bertrand et al. 2004, Wooldridge 2002). Columns 1, 3, and 5 include village fixed effects whereas columns 2, 4, and 6 include mother fixed effects. In the columns with mother fixed effects, the identification of $\hat{\beta}_3$ comes from within mother variation in mortality and hence relies on mothers who had births before and after Dodd Frank. Columns 1 and 2 include year effects, columns 3 and 4 include province-specific year effects, and columns 5 and 6 include territory-specific linear trends. All columns include month-of-birth fixed effects and controls for rainfall, birth order, and infant gender. The specifications with village fixed effects also include time-invariant controls for household size, mother education, marital status, and literacy.

Turning to the key results, $\hat{\beta}_3$ is positive and statistically different from zero in all six specifications. This result indicates that under-1 mortality rates after Dodd-Frank increased in the treated villages relative to the counterfactual villages. For perspective on magnitudes, the mean mortality probability in the treated villages prior to Dodd Frank was 0.060. Hence, after controlling for other factors, the column 1 estimate of 0.086 implies that Dodd Frank increased under-1 mortality probabilities by 143%. The effects are even larger for our favored specifications with mother fixed effects, in columns 2, 4 and 6.

The $\hat{\beta}_2$ estimates are significant and negative in 4 of 6 specifications, suggesting that being close to a 3T mine would have lowered relative mortality rates in the absence of Dodd Frank. The finding that $\hat{\beta}_1$ is statistically insignificant in 5 of 6 specifications suggest there was no measurable effect of the policy on infant mortality in villages >20km from mines. The finding that $\hat{\beta}_3 + \hat{\beta}_1 > 0$, which is consistent across all specifications, indicates that post-Dodd Frank mortality inside the policy zone increased in 3T mining villages relative to post-Dodd

Frank changes in the 3T mining villages outside the policy zone as suggested by figure 5. The finding that $\hat{\beta}_3 + \hat{\beta}_2 > 0$ indicates that post-Dodd Frank mortality inside the policy zone increased in 3T mining villages relative to post-Dodd Frank changes in villages >20km from mines inside the policy zone as suggested by figure 6.

The fact that the *Post DF x Gold Ind. x Policy Zone* coefficients, $\hat{\beta}_5$, are effectively zero in all specifications also bolsters the evidence that a Dodd Frank-induced boycott, rather than confounding factors, caused the under-1 mortality increase. Dodd Frank did not cause a widespread slowdown in gold mining and hence we do not expect the policy to have had an adverse impact on mortality in villages near gold mining sites through the income channel. If confounding factors (specific to mining-dependent in policy zone villages) were driving our estimates of $\hat{\beta}_3$ we would expect them to be present in gold mining areas and produce significant effects on $\hat{\beta}_5$, which we do not see.

Turning to the covariates in table 2, which are not our focus, we note the following patterns. First, abnormal rainfall after birth increases mortality rates whereas rainfall pre-birth decreases mortality. Abundant pre-birth rainfall may lower mortality rates by increasing food and income via improved post-birth agricultural harvests. Abundant post-birth rainfall may raise mortality rates by increasing risk of diseases such as malaria and diarrhea, or by making medical and food supplies more difficult to transport under wet conditions.[27] Second, birth order positively correlates with mortality, meaning that earlier births have higher mortality, perhaps because first births in the DRC are often to younger, inexperienced teenage mothers. Third, male infants have higher mortality rates; this finding is consistent with a large literature in epidemiology on male mortality disadvantage (see, e.g., Drevenstedt et al. 2008). Fourth, larger sized households have lower mortality rates, perhaps because larger households have more people in them to take care of infant children, as found, for example, in Han and Foltz (2015).

### *D. Robustness Checks*

Table 3 shows the main results pass three important robustness checks. In panel 2, we substitute the 3T and Gold Indicator variables with 3T and Gold variables that measure the *number* of mines within 20km of a village. This modified specification allows the treatment

[27] When we omit the rainfall variables from the specifications, the estimates of the Dodd Frank policy effects are nearly identical. This is not surprising because the variation in rainfall shocks is not correlated with the spatial-temporal variation in 3T mine location in the post-Dodd Frank period.

effect to vary with the intensity of pre-Dodd Frank mining, assuming the number of mines is a good proxy for mining intensity. The results show the estimated impacts of the policies on mortality increases with the number of nearby 3T mines. The column 1 coefficient of $\hat{\beta}_3$ =0.016, for example, suggests that mortality probabilities increased by 0.016 for every nearby 3T mine. For treated villages, the mean number of nearby 3T mines was 4.17. Hence, the effect for the average treated village was 4.17 x 0.016 = 0.067. This is a 111% increase in mortality relative to the 0.06 pre-Dodd Frank mean in these villages.

Panel 3 omits births during 2010 to test the sensitivity of the main results to our assumption that Dodd Frank treatment began in July 2010, before the formal electronics industry boycott. As the results indicate, the treatment effect remains positive, large, and statistically significant. We conclude that our main inferences do not hinge on the assumption that treatment began with the passage of Dodd Frank.

Panels 4 and 5 accommodate spatial correlation in estimation errors across villages. In panel 4, we cluster standard errors by territory to account for the possibility that villages within the same territories were exposed to a common set of regional factors that affect mortality. In panel 5, we create cluster groups of villages that are within 20km from the same 3T mine. This procedure accommodates the possibility that mortality in villages relying on the same mine were similarly affected by (unobserved) changes in mine activity. Although the standard errors increase in some of these specifications, the coefficients remain statistically significant in 9 of 12 specifications, including the most demanding specifications with mother fixed effects. In columns 1 and 3, the p-values on the treatment coefficients are close to $p<0.10$, at 0.14 and 0.11 in panel 4 and 0.12 in panel 5.

In table 4, we examine the robustness of the main results to different distance criteria for defining the mining status of villages. Here we define that status as within 10km, 20km, 30km, 40km, and 50km of a 3T mine.[28] As panels 1-3 of table 4 illustrate, the estimated treatment effects decline with distance thresholds, moving from 10km to 50km. This is an empirical pattern consistent with the income benefits from mining declining with village distance from a mine. The empirical pattern also suggests that any local effect of 3T mining pollution on under-1 mortality – such as those effects that may be realized only within 10km of a mine - are dominated by mining related income effects.

[28] The online appendix shows the number of treated and control villages and births at these different distance thresholds.

We also estimate the same models using a different 'neonatal' mortality outcome: children who died within one month of birth.[29] The detailed results are given in the online appendix, Table A2, for distance thresholds of 10km, 20km, 30km, 40km, and 50km. We estimate a positive effect of Dodd Frank on neonatal mortality, with coefficient estimates ranging from 0.053 to 0.108. For perspective, the mean neonatal mortality for treated villages prior to Dodd Frank was 0.028. Hence, the smallest coefficient of 0.053 represents a 0.053/0.028 = 189% increase from the baseline. These effects are larger than the estimated effects on under-1 mortality, which is smallest at 143%. However, the effects on neonatal mortality are statistically significant only up to a threshold of 20km whereas the effects on under-1 mortality remain significant up to a threshold of 30km. These subtle differences might help distinguish mechanisms from Dodd Frank to higher mortality, as discussed in section 6.

To summarize the results in this section, the findings are consistent with Dodd Frank, and the related policies, causing a statistically significant and quantitatively large increase in under-one mortality. The effect is robust to the inclusion of mother fixed effects, different spatial and temporal definitions of 'treatment', and the accommodation of region and territory specific trends in mortality, and to another definition of infant mortality. In most cases, tests of gold mining fail to generate a similar pattern of results. This collection of results makes a strong case that a Dodd Frank induced boycott, rather than confounding factors, caused the higher mortality. In the next section, we examine potential channels through which mortality increased.

## 6. Channels from Legislation to Higher Infant Mortality

In section 3, we described three main channels through which the conflict mineral policies may have increased infant mortality. First, the policies may have caused more conflict in mining areas. Second, the policies may have reduced income streams to families and communities previously dependent on artisanal mining. Third, the policies may have reduced availability and access to medical care. We examine the channels below and also discuss the potential role of selective migration out of 3T mining areas.

### *A. Armed Conflict*

[29] The average sample value is 0.036, meaning that 36 of 1000 infants died within one month. By comparison, 72 of 1000 infants in the sample died within 12 months of birth.

To test for the extent to which armed conflict might be an important channel, we add child-specific conflict measures to the right-hand side of the econometric model described in Equation (1) above. If conflict is an important channel, then we expect the treatment effect coefficient to decrease once we add controls for conflict. We measure the number of armed conflicts within a 20km radius of each DHS village during the 12 months following each child's birth using data from the Armed Conflict Location and Event Dataset (ACLED).[30] This dataset provides information on internal conflict disaggregated by date, location, and by actor or actors for a number of African countries, including the DRC.[31] We measure the number of conflicts in total, as well as measures disaggregated into 'battle' and 'violence against civilians' categories. The mean number of conflicts for each of the 7,697 infants in our study was 5.01 over 2007-2012, with a standard deviation of 15.26. Of the children in the sample, 36% were exposed to at least one conflict event (within 20km) within the first 12 months following their birth.[32]

Table 5 shows the results. Some specifications employ aggregate measures of conflict and other specifications employ the disaggregated measures. Other specifications include indicators for whether or not a conflict event occurred, rather than the number of conflict events. Regardless of how conflict is measured, the table 5 results indicate that controlling for conflict has almost no impact on the size of the policy treatment coefficients. Overall, the table 5 estimates suggest that conflict was not an important channel through which Dodd Frank increased infant mortality.

The coefficient estimates on the conflict variables in table 5 provide some evidence that conflict exposure within the first year increases infant mortality in terms of statistical significance, though less clearly in terms of magnitudes. To put these estimates into perspective, consider the panel 2, column 5 coefficient of 0.00074 (which is rounded up to 0.001). This coefficient means that an additional conflict within 20km of a child's village (during the 12 months after birth) is associated with a 0.00074 increase in the probability of the infant dying.[33] To put this number in perspective, a reduction in exposure from 5.01, the

[30] We choose the ACLED data set, rather than alternatives such as the Uppsala Conflict Data Program (UCDP) because the ACLED data set measures more events – such as those not resulting in fatalities – that could affect infant mortality.
[31] The ACLED data are available at www.acleddata.com and are described in Raleigh et al. (2010). Several economics and political science articles employ the ACLED data (see, e.g., Minoiu and Sehmyakina 2014). Other economics studies also employ ACLED data from the DRC including Maystadt et al. (2014), Pellillo (2012), and Parker and Vadheim (2017).
[32] The online appendix shows summary statistics.
[33] These comparisons are informative but estimating the causal effect of conflict on infant mortality is not our main focus. By contrast, a working paper by Dagnelie et al. (2015) focuses on trying to estimate the effect of

sample mean, to 0 would reduce the probability by 0.0037 or 3.7 per 1000 births. In section 7, we interpret the coefficients in terms of how much infant mortality could be eliminated if Dodd Frank were eventually successful in eliminating armed conflict exposure.

### *B. Consumption of Health Care*

To study the health consumption channel, we cannot rely on only the 2013 DHS survey wave because it contains only cross-sectional information about a mother's income and health, except for recall data on child mortality. Instead, we draw from both the 2007 and 2013 DHS survey waves. Using both surveys, we create a data set of health care consumption outcomes covering pre and post Dodd Frank time periods. The data set is similar to, but not quite, a repeated cross section of villages because different villages within similar enumeration areas are represented in the different survey years. This means we cannot include village (or mother) fixed effects in econometric models.

The 2007 and 2013 DHS surveys include several variables that are candidate measures of a mother's wealth and health care consumption. The candidate outcomes that we examined are: 1) a wealth index based on an assessment of family assets; 2) whether or not the respondent was employed; 3) whether or not the respondent's partner was employed; 4) whether or not the mother (presumably with infant) slept under a bednet; 5) whether or not the mother had prenatal care for her most recent birth; 6) whether or not the mother visited a health facility while pregnant for her most recent birth; 7) whether or not the mother reported money as being a constraint to getting prenatal care; 8) whether or not the mother reported distance to a health care facility as being a constraint to getting prenatal care; and 9) whether or not the mother received birth assistance from a health care practitioner.

To trim this list down to the subset of variables most likely to affect under-one mortality, we performed the following analysis. First, we added each of the nine 2013 survey outcomes, individually, to the right-hand side of the columns 1, 3, and 5 regression specifications shown in table 2. The purpose was to identify which outcomes are most robustly related to infant mortality. Note that this exercise is possible for the specifications with village fixed effects, but it is not possible for the specifications with mother fixed effects because these are mother-level variables. The results show the following variables to be related to infant mortality: a) whether or not the mother slept under a bednet; b) whether or

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conflict during the 1997-2004 DRC civil war on infant mortality. They conclude that conflict affected mortality for girls, but not for boys. For girls, their coefficients appear to be larger in magnitude than ours but the results are not directly comparable because their analysis is at a more aggregated spatial level – the 38 districts of the entire DRC – and because their study spans a period of war when mortality rates were generally higher.

not the mother had prenatal care; c) whether or not the mother had a prenatal visit at a health facility.[34] All of these indicator variables, which equal 1 if yes, have negative relationships with infant mortality probabilities at the mother level. Because the prenatal care and prenatal visit variables are highly correlated (ρ=0.94), we analyze only prenatal care but the results are nearly identical for prenatal visits.

The literature shows strong evidence that mothers sleeping under bednets reduces diseases such as malaria that can cause infant mortality (Killeen et al. 2007), but also that purchase and use of bed nets in African countries is very price sensitive (Dupas 2009 and Dupas 2014). This latter feature of bednets implies that it is a health good susceptible to income shocks, such those potentially caused by a Dodd Frank-induced boycott. In the eastern DRC sample, only 19.3% of the mothers slept under bednets in 2007 compared to 58.3% in 2013. This growth is consistent with the general increase in bednet use across sub-Saharan Africa during the same time frame due to better availability, lower prices and concerted information campaigns. There is less of an upward trend in prenatal visits in part due to already high levels in the baseline 2007 data; 83.7% of mothers reported prenatal care for their most recent birth in the 2007 survey compared to 87.3% in the 2013 survey. Note that, for the prenatal care variable, we compare births occurring in 2007 to births occurring during 2010-2012 to most precisely capture the potential Dodd Frank effects.

To study the potential effects of the conflict minerals legislation on these outcomes, we estimate a regression model similar to our main regression estimates in Equation (1), although we cannot include mother or village fixed effects. Another key difference is that here we do not control for weather shocks because we cannot link the timing of bednet use and prenatal care to these shocks. Aside from these key differences, however, the econometric specifications are similar to those in (1). More specifically, we estimate the following econometric model.

$$\begin{aligned}
&outcome_{mvtpy} = \alpha_t + (\mu_{2013} \text{ or } \delta_{2013\times p}) + \gamma X_m + \lambda_1(3TInd_v) + \\
&\lambda_2(3TInd_v \times PolicyZone_v) + \lambda_3(PolicyZone_v \times y_{2013}) + \lambda_4(3TInd_v \times PolicyZone_v \times y_{2013}) \\
&+\omega_1(Gold_v) + \omega_2(Gold_v \times PolicyZone_v) + \omega_3(GoldInd_v \times PolicyZone_v \times y_{2013}) + \varepsilon_{mvtpy}.
\end{aligned} \tag{2}$$

[34] While it may seem surprising that the DHS assets index, the only available measure of income, is not strongly correlated with infant mortality outcomes, this is likely because the asset index measures much longer-term accumulation including measures of a number of non-liquid assets that are not available to feed or care for children, such as the type of roof, floor and plumbing. It may also seem surprising that the employment variables are not correlated with infant mortality. However, these employment variables may not be very meaningful because the number of partners reported to be unemployed is very low (1% in 2013 and 4% in 2007), and this variable is reported only for ever-married women (68% of the sample in 2007 and 75% in 2007).

Here $m$ = mother, $v$ = village, $t$= territory, $p$= province, and $y$ = 2007 or 2013. The term $\alpha_t$ denotes fixed effects for each of the 70 eastern DRC territories. The term $\mu_{2013}$ denotes the individual, area-wide year effect for the 2013 survey, while other specifications allow each of the five provinces to have their own 2013 effects ($\delta_{2013\times p}$).

The $\lambda$ coefficients are of primary interest, particularly $\lambda_4$, which is the triple difference estimate of the policy effect on bednets and prenatal health usage. A finding that $\hat{\lambda}_4 < 0$ implies that a mother's consumption of health care goods and services decreased over 2007-2013 in treated villages, relative to consumption in the control group villages. As before the control group villages are a) within 20km of 3T mines outside the policy zone and b) inside the policy zone but >20km from a 3T mine.

Table 6 shows the results from linear probability estimates of Equation (2). All specifications include mother level covariates such as education, household size, marital status, literate, and age. Columns 1-2 include area wide 2013 effects and columns 3-4 include province specific 2013 effects. All standard errors are clustered at the territory level.[35]

The key coefficients, $\hat{\lambda}_4$, are negative in all specifications and statistically significant in 3 of 4 specifications. Although these specifications are not as rigorous as the mortality estimates, the evidence in table 6 is consistent with Dodd Frank increasing infant mortality through a reduction of mother consumption of prenatal care and disease-reducing bednets. Recalling the general trend of rising bednet use, the coefficient of -0.182 a causal interpretation is that bednet use was 18.2 percentage points lower in treated villages relative to how much bednet use would have grown without the Dodd Frank-induced boycott. Given the price sensitivity of bednet usage found in Africa by Dupas (2009, 2014), it is plausible that negative shocks to family income induced by the Dodd Frank boycott drove the decreases in health care consumption. The decreases in health care consumption could have also been driven by reductions in access to or increases in the price of health care goods and services in the treated villages, due to a decrease in the transport of goods and services into those villages as their economic importance declined with the mineral boycott.[36]

[35] Clustering at the village level is not an option because different villages were surveyed in 2013 and 2007. Clustering at the territory level accommodates the possibility that villages within the same territories were exposed to a common set of factors influencing health care consumption.
[36] In the online appendix, we show that estimated effects of Dodd Frank on neonatal mortality are relatively larger than the effects on under-1 year mortality. However, the neonatal effects dissipate at a distance of 20km to 3T mines compared to a threshold at 30km for under-1 mortality. This subtle difference adds another piece of evidence to suggest that diminished access to health care is a key channel. Our reasoning is as follows. If neonatal mortality is more sensitive to access to nearby (e.g., <20km) health care facilities than under-1

The other coefficient estimates in table 6, which are not our focus, make intuitive sense. The positive and generally significant $\hat{\lambda}_2$ coefficients suggest that mother's consumption of health care increased more than average in villages near 3T mines, perhaps because of the high world prices of 3Ts during 2010-2012. These positive estimates on $\hat{\lambda}_2$ provide a counterfactual for what may have happened to health care consumption near 3T mines in the absence of Dodd Frank. The coefficients on the mother level variables all sensibly show that measures of human capital (e.g., education, literacy, age) relate positively to health care consumption.[37]

### *C. Migration*

The conflict mineral policies likely caused migration out of the treated villages. This raises two important questions for our analysis. The first is: are the regression coefficients measuring the causal effect of the policies on mothers who stayed in 3T mining villages, or do they reflect a change in demographic composition of mothers due to selective migration? The second is: what would have happened to the mothers who moved if they would have instead stayed?

In the mother recall data on mortality, all 2007-2012 births are tied to the location of a mother's residence in 2013 because the 2013 DHS data do not indicate location at time of birth.[38] This data shortcoming inhibits a fuller understanding of how migration may have mitigated or exacerbated impacts of Dodd Frank on infant mortality. In spite of this, we still think our estimates with mother fixed effects likely reflect the important causal effect of the policies on mothers who were in 3T mining villages before and after the policies.

We illustrate our reasoning in more detail in the online appendix, but here we lay out the main arguments. If Dodd Frank caused mothers more prone to infant mortality to migrate out of 3T mining villages during 2010-2012, then the solid line in figures 5 and 6 would understate the true mortality rates of this group, both before and after Dodd Frank. Although levels of mortality rates are affected by this type of selective migration, the before versus after *difference* in mortality is not affected because all birth outcomes are attributed to the

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mortality, and Dodd Frank reduced such access, then we would expect larger effects on neonatal mortality that are more sensitive to distance thresholds.

[37] The estimates of the gold mining treatment coefficients, $\hat{\omega}_3$, are statistically related to the outcomes in several specifications but the signs and significance follow erratic patterns and are sensitive to our treatment of time effects. For these reasons, we are not confident that the estimated relationships reflect true, robust patterns and therefore do not make causal claims based on them.

[38] The DHS 2007 surveys for DRC asked respondents if that had moved recently, the 2013 survey wave did not.

same, 2013 mother's village. This is important because our econometric strategy with mother fixed effects identifies treatment effects from differences, rather than levels, of mortality outcomes before and after Dodd Frank from the subset of mothers who had children during both time periods. Similarly, if Dodd Frank caused mothers less prone to infant mortality to migrate out of 3T mining villages during 2010-2012, then the solid line in figures 5 and 6 would overstate true mortality. But here again, the difference in mortality is not affected.

A comparison of table 2 coefficient estimates with and without mother fixed effects provide some clues about the direction of selective migration. This is because the coefficients without mother fixed effects are potentially influenced by selective migration because they are estimated from models that do not constrain before and after comparisons to infants from the same mother. As table 2 indicates, the coefficients are larger with mother fixed effects. Based on the logic above, this suggests that selective migration was in the direction of mothers with greater risk of infant mortality leaving the treated villages after Dodd Frank.

While the infant mortality coefficients generated with mother fixed effects should validly estimate the causal effects on mothers who stayed, the health care consumption coefficients are likely affected by selective out migration if the covariate controls for mother characteristics in table 6 fail to fully control for a changing demographic makeup. The use of repeated cross-sections implies that differences between 2007 and 2013 outcomes might reflect a different demographic composition of mothers after, versus before, the policy. For example, if mothers more in need of health care migrated out of 3T mining villages, as suggested by the comparison of mortality estimates with and without mother fixed effects, then this would decrease the estimated effect of the policy on health care consumption relative to a situation in which no selective migration occurred. Hence, the table 6 specifications may understate the effect of the policy on the health care consumption of mothers who stayed.

What would have happened to the mothers who moved, in response to the sanctions, if they would have instead stayed? We can offer the following thoughts. First, we presume such mothers moved to mitigate adverse effects, at least in expectation. If this is true, then some of the adverse effects of the sanctions were avoided by mothers having the means, support, and opportunity to migrate elsewhere. This reasoning implies that factors encouraging family mobility, such as Dodd Frank's inability to effectively regulate gold mining, could have softened the countrywide negative effects. Moreover, factors that enable migration, such as job opportunities outside of mining areas, could also help to limit the control of armed militia groups, which is a point we return to in the paper's conclusion.

## 7. Discussion and Auxiliary Analysis

The evidence thus far indicates the conflict mineral policies caused increased infant mortality in 3T villages within the policy zone, and that this increase was plausibly driven by a decrease in mother health care consumption. In this section, we consider heterogeneous infant mortality effects across these 'treated' villages. We also conduct a thought experiment to compare the short-run, adverse impacts on infant mortality with potential long-run benefits if the sanctions were ultimately successful at eliminating armed-group conflict.

### *A. Effects from Intended and Unintended Boycotts*

A key source of heterogeneity to identify mines that were intentionally versus unintentionally boycotted is the presence of an armed group at a mine prior to the Dodd Frank legislation, which sought to "cut off funding to people who kill people" (Aronson 2011). Although one might consider higher infant mortality near mines with an armed group as necessary collateral damage from a well targeted policy, the infant mortality effects near non-targeted mines operated by non-targeted operators falls into another category of unintended consequences: poor targeting.

Table 7 shows tests for heterogeneous mortality effects, based on the number of 3T mines with and without an armed group presence within 20km of a policy-zone village.[39] Panel 2 shows that point estimates of mortality effects are larger for 3T mines with an armed group presence in 5 out of 6 specifications. The point estimates, however, are also positive and statistically significant for 3T mines without an armed group presence and, in most specifications, not statistically different from the estimates for 3T mines with armed groups. These 3T mines lacking armed groups were not explicit targets of Dodd Frank but, based on table 7 results, the nearby villages appear to have also lost infant lives by being subjected to a *de facto* boycott.

Panel 3 further disaggregates the 3T mining policy villages by separating the armed groups into two categories: rebel and government militias.[40] The explicit goal of Section

[39] Of the 23 villages near a 3T mine in the zone, 14 were near at least one mine with an armed group presence and 15 were by at least one mine without an armed group presence. There were 7 policy zone villages <20km from both types of 3T mines. At the mine level, there were 213 3T mines in the policy zone and 34.3% had an armed group presence.

[40] The rebel armed groups in the IPIS maps (see Spittaels and Hilgert 2009 and Spittaels 2010), include the Forces for the Liberation of Rwanda (FDLR), the Forces Républicaines Fédéralistes (FRF), and Mayi Mayi militias (an umbrella term for loosely affiliated groups of local militias). The government armed groups include the Armed Forces of the Democratic Republic of Congo (FARDC) and the National Congolese Police (PNC). Of the 14 villages near at least one armed group controlled 3T mine, 8 were near a rebel controlled mine and 11

1502 was to reduce funding to illicit armed militias (i.e., rebel groups). In contrast to rebel groups, the DRC's government militias may have been considered legitimate actors by companies who attempted to acquire conflict free minerals and thus potentially exempt from the policy. In both panels, consistent with rebel-controlled mines being the most directly targeted by the boycott, the point estimates of mortality effects are largest for the rebel-controlled mines because there are smaller statistically significant infant morality effects from being near government militia controlled mines. As in panel 2, however, the differences in point estimates between armed groups and other mine owners are not always statistically significant suggesting the boycott was blunt and imprecisely targeted.

Why was the targeting so blunt and what could have been done differently? Commentary by a group of experts, in an open letter published by the DRC's Pole Institute in 2014, provides ideas. The letter argues, among other things, that a key flaw of the conflict minerals legislation is that it demanded companies prove the origin of minerals well before monitoring systems able to provide such proof were in place.[41] This resulted in the de facto boycott. A better approach, perhaps, would have been to give companies waivers for compliance until monitoring systems were in place, or create a default rule in which minerals were considered conflict free unless proven otherwise.[42]

### *B. Thought Experiment on Short versus Long Run Effects*

The long run effects of Dodd Frank may be more positive for infant mortality than estimated by our short-run analysis. Here we consider, as a thought experiment, how the short-run costs compare with potential long-run benefits under the extreme assumptions that 1) 3T mining in the eastern DRC eventually fully resumes and 2) armed conflict is eventually eliminated by conflict mineral regulations.

To conduct the thought experiment, we return to Table 5, which shows relationships between armed conflict and infant mortality. Suppose Dodd Frank reduces conflict incidents across the entire policy zone from the 5.24 mean prior to Dodd Frank, to zero. Further suppose 3T mining resumes so that there is no longer an adverse effect of Dodd Frank

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were near a government controlled mine. Four villages were near both types of 3T mines. At the mine level, 29% of the 3T mines in the policy zone were visited regularly by rebel groups.

[41] The letter is online at www.pole-institute.org/news/open-letter-conflict-minerals-drc, as of January 6, 2017.

[42] The targeting problem is similar, in some ways, to the dilemma faced by military operators when considering whether to bomb an enemy when the bombing will harm enemies and civilians. One key difference is that the sanctioning entity – the U.S. government in our study – does not directly control sanction implementation. Companies ultimately controlled implementation, by deciding how to change their purchasing tactics in response to the new incentive structure created by the regulations. This lack of direct control suggests, perhaps, that sanctions are fundamentally doomed to be less precise in their targeting.

through health consumption and related channels. Taking the largest coefficient estimate on conflict incidents in panel 2, which is 0.00074 in column 5, the long-run probability of infant mortality would fall by 0.00074 *x* 2.02 = 0.0015 due to the elimination of conflict. By comparison, our most conservative estimate suggests that Dodd Frank increased the short-run mortality probability by 0.086, where the 'short-run' is approximately 2.5 years (July 2010-December 2012). To compare short and long run effects under this scenario, we account for the fact that only 29% of sample births in the policy zone were in villages within 20km from 3T mines. Hence, if the adverse short run effect for villages near 3T mines is eliminated and replaced by a beneficial long-run effect of conflict elimination in all policy zone villages, then a net benefit would be realized in a time span that is (0.086 *x* 2.5 *x* 0.29)/0.0039 = 16 years. If we discount the value of a human life in future years at a rate of 1%, 3%, and 5%, the time span is 18, 25, and 35 years respectively. At annual discount rate of 7%, the long run benefits would never exceed the short run costs. If the policy does not start reducing conflict until some future year, then it would not be justified at lower discount rates: for example, at a discount rate of 5%, the long run benefits will not exceed the short run costs if the long run benefits do not begin to accrue until 10 years after 2012.

The back-of-the envelop calculations just described are rough, and they reflect a sort of best-case scenario for several reasons. First, they assume that *all* armed conflicts are eliminated in the long-run and that negative short-run impacts do not linger beyond our time period of analysis. Second, the calculations combine the most conservative estimate of adverse short-run effects – the 0.086 coefficient – with the least conservative estimate of the adverse effects of conflict – the 0.0074 coefficient. Still, even under these extreme assumptions, the calculations highlight how the annual short-run costs are significant orders in magnitude higher than then the potential long run benefits. [43]

Why are the annual short-run costs so much higher than the potential long-run benefits in these thought experiments? First, infant mortality was quite sensitive to disruptions directly and immediately impacted by sanctions, such as health care consumption. Second, infant mortality was not very sensitive to the presence of nearby armed conflicts, which is the activity Dodd Frank aims to reduce over a longer period of time.

## 8. Conclusion

[43] The calculations possibly understate the potential long run benefits to infant mortality if the policy can reduce indirect effects of armed conflict on infant mortality, for example by enabling higher worker productivity and earnings in a conflict free environment. We do not attempt to incorporate this potential effect into the calculations because we do not have empirical estimates for guidance.

When citizens of developed nations pressure their governments to protect vulnerable populations in foreign lands, they often request economic sanctions to punish human rights violators with the goal of generating positive change. In the case we study, human rights advocacy groups successfully lobbied for Section 1502 of the U.S. Dodd Frank Act, which effectively reduced international demand for Congolese 3T minerals. While this policy appears to have had one of its intended effects, reducing militia revenue from 3T mining, evidence here demonstrates it has also produced unwanted effects that were borne by the vulnerable populations the policy sought to help.

The findings highlight the general problem with sanctions: it is difficult to withhold economic transactions from perpetrators of abuses without the brunt of the effects being absorbed by the victims (see, e.g. Allen and Lektzian 2012). In the case of Dodd-Frank, its success in slowing 3T mining has generated two kinds of unintended consequences. First, infant mortality rates rose in villages whose economic fates are tied to intentionally boycotted, armed group controlled 3T mines. Second, infant mortality rates also increased in villages whose economic fates are tied to unintentionally boycotted, and potentially 'conflict free', minerals. This second type of unintended consequence is arguably more regrettable, and it suggests important flaws in this and potentially other conflict free certification programs. High transaction costs of following supply chains from source to product can produce unintentional boycotts. Rather than absorbing costs and the associated reputational risk of not appearing socially responsible, companies may simply choose to source elsewhere.

These results should serve as a cautionary tale for policy makers considering sanctions or certification programs, and they also provide a counterpoint to concerns that mining in developing countries is detrimental to child health. On the contrary, we find that infant survival in the eastern DRC positively corresponded with world 3T prices when and where Dodd Frank sanctions were absent. Moreover, infant mortality was lower in villages near conflict mines prior to Dodd Frank, suggesting mining activity generated health benefits even in this setting with armed militias and weak formal governing institutions. While living close to a mine that helps finance militias may not be ideal, the results here suggest that worse health outcomes occur when the mine near one's home is boycotted.

Although our research casts a dim light on the success of the Dodd–Frank human rights policy, it does not imply that such unwanted consequences are inevitable. A better-targeted certification programme could, potentially, cause less collateral damage, especially if it were offset with commensurate healthcare and income aid to help families near mining villages. Advocates of Dodd–Frank Section 1502 could argue the legislation needs more time to work, and it is possible that long-run benefits for infant health will eventually emerge if the legislation can reduce conflict exposure and enable mining to resume. Even if does, it is worth asking if the short run human costs that have already been absorbed were justified. Our calculations here, although inexact, suggest it would take a long period of sustained benefits, and conservative discounting of the future, to justify the short run impacts.

It is also worth asking what might have happened if the money spent on Section 1502 compliance and lobbying – reportedly a billion U.S. dollars - was instead spent on alternative forms of foreign aid for human rights. Could an alternative policy – one that leveraged a budget of a billion dollars - have been more effective at reducing militia control while at the same time benefiting local populations? We do not have a detailed blueprint to propose, but there is a general strategy that economists might endorse: use foreign resources to raise the opportunity cost of engaging in conflict. If foreign policy can successfully raise the opportunity cost to young men of militia participation, then conflict might be reduced through voluntary exit out of militias or out of risky mining areas (see, e.g., Blattman and Annan 2016). Foreign interventions that create better opportunities in rural areas (e.g., jobs, schools, or health clinics), or that reward ‘conflict free minerals’ rather than penalizing ‘conflict minerals’ might achieve this, and at least not boycott a region where jobs, income, and health care are already scarce.

## 8. References


Akresh, Richard, Sonia Bhalotra, Marinella Leone and Una Okonkwo Osili. 2012. "War and Stature: Growing up During the Nigerian Civil War." *American Economic Review* 102(3): 273–77.

Akresh, Richard, Leonardo Lucchetti and Harsha Thirumurthy. 2012. "Wars and Child Health: Evidence from the Eritrean-Ethiopian Conflict." *Journal of Development Economics* 99(2): 330–40.

Allen, Susan H. and David J. Lektzian. 2012. "Economic Sanctions: A Blunt Instrument?" *Journal of Peace Research* 50(1): 121-135.

Almond, Douglas, Kenneth Y. Chay and David S. Lee. 2005. "The Cost of Low Birth Weight." *Quarterly Journal of Economics* 120(3): 1031–83.

Aragón, Fernando M., Punam Chuhan-Pole and Bryan C. Land. 2015. "The Local Economic Impacts of Resource Abundance: What Have We Learned?" World Bank Policy Research Working Paper No. 7263. Washington, DC: World Bank.

Aragón, Fernando M. and Juan Pablo Rud. 2013. "Natural Resources and Local Communities: Evidence from a Peruvian Gold Mine." *American Economic Journal: Economic Policy* 5(2): 1–25.

Aragón, Fernando M. and Juan Pablo Rud. 2016. "Polluting Industries and Agricultural Productivity: Evidence from Mining in Ghana." *Economic Journal* 126(527): 1980-2011.

Aronson, David. 2011. "How Congress Devastated Congo." *New York Times*, August 7. Available at: www.nytimes.com/2011/08/08/opinion/how-congress-devastated-congo.html (accessed on 7 June 2012).

Autesserre, Séverine. 2012. "Dangerous Tales: Dominant Narratives on the Congo and their Unintended Consequences." *African Affairs* 111(443): 202–22.

Bafilemba, Fidel, Timo Mueller and Sasha Lezhnev. 2014. "The Impact of Dodd-Frank and Conflict Mineral Reforms on Eastern Congo's Conflict." Enough Project. Available at: www.enoughproject.org/reports/impact-dodd-frank-and-conflict-minerals-reforms-eastern-congo per centE2 per cent80 per cent99s-war (accessed on 15 November 2015).

Barry, Michelle. 2000. "Effect of the US Embargo and Economic Decline on Health in Cuba." *Annals of Internal Medicine* 132: 151–4.

Bawa, Yves. 2010. "Promines Study: Artisanal Mining in the Democratic Republic of Congo." Available at: www.pactworld.org/galleries/resourcecenter/PROMINES per cent20Report per cent20English.pdf (accessed on 8 June 2012).

Bayer, Chris N. 2015. "Dodd Frank Section 1502: Post Filing Survey 2014." PowerPoint Presentation, Development International. Available at: http://www.payson.tulane.edu/sites/default/files/content/files/TulanePaysonS1502PostFilingSurvey.pdf (accessed on 20 June 2016).

Bertrand, Marianne, Esther Duflo and Sendhil Mullainathan. 2004. “How Much Should we Trust Differences-in-differences Estimates?” *Quarterly Journal of Economics* 119(1): 249–75.

Blattman, Christopher and Jeannie Annan. 2016. “Can Employment Reduce Lawlessness and Rebellion? A Field Experiment with High-Risk Men in a Fragile State.” *American Political Science Review* 110(1): 1-1.

Bundervoet, Tom, Phillip Verwimp and Richard Akresh. 2009. “Health and Civil War in Rural Burundi.” *Journal of Human Resources* 44(2): 536–63.

Buonanno, Paolo, Ruben Durante, Giovanni Prarolo and Paolo Vanin. 2015. “Poor Institutions, Rich Mines: Resource Curse in the Origins of the Sicilian Mafia.” *Economic Journal* 125(August): F175–F202.

Camacho, Adriana. 2008. “Stress and Birth Weight: Evidence from Terrorist Attacks.” *American Economic Review* 98(2): 511–15.

Carisch, Enrico. 2012. “Conflict Gold to Criminal Gold: The New Face of Artisanal Mining in Congo.” South Africa Resource Watch. Available at: www.osisa.org/other/economic-justice/drc/conflict-gold-criminal-gold-new-face-artisanal-gold-mining-congo (accessed on 9 March 2013).

Caselli, Francesco and Guy Michaels. 2013. “Do Oil Windfalls Improve Living Standards? Evidence from Brazil.” *American Economic Journal: Applied Economics* 5(1): 208-238.

Chunan-Pole, Punam, Andrew L. Dabalen, Andreas Kotsadam, Aly Sanoh and Anja K. Tolonen. 2015. “The Local Socioeconomic Effects of Gold Mining: Evidence from Ghana.” World Bank Policy Research Working Paper WPS7250.

Climatic Research Unit. 2015. “High-Resolution Gridded Datasets.” Available at: https://crudata.uea.ac.uk/cru/data/hrg/ (accessed on 22 August 2016).

Cuvelier, Jeroen, Koen Vlassenroot and Nathaniel Olin. 2014. “Resources, Conflict and Governance: A Critical Review.” *The Extractive Industries and Society* 1: 340–50.

Dagnelie, Oliver, Giacomo De Luca and Jean-Francois Maystadt. 2015. “Do Girls Pay the Price of Civil War? Violence and Infant Mortality in Congo.” Working Paper. Available at: http://cega.berkeley.edu/assets/miscellaneous_files/116_-_dagnelie_deluca_maystadt_congo-_ABCA.pdf (accessed 15 November 2015).

Deacon, Robert T. 2011. “The Political Economy of the Natural Resource Curse: A Survey of Theory and Evidence.” *Foundations and Trends in Microeconomics* 7(2): 111–208.

Drevenstedt, Greg L., Eileen M. Crimmins, Sarinnapha Vasunilashorn and Caleb E. Fincch 2008. “The Rise and Fall of Excess Male Infant Mortality.” *Proceedings of the National Academy of Sciences* 105(13): 5016–21.

D’Souza, Kevin. 2007. “Artisanal Mining in the DRC: Key Issues, Challenges and Opportunities.” Available at: http://www.ddiglobal.org/login/Upload/CASM- per cent20ASM per cent20in per cent20DRC per cent20briefing per cent20note.pdf (accessed on 7 June 2012).

de Haas, Ralph and Steven Poelhekke. 2016. “Mining Matters: Natural Resource Extraction and Local Business Constraints.” Working Paper. Available at SSRN: http://ssrn.com/abstract=2783443 (accessed on June 13, 2016).

de Koning, Ruben. 2011. “Conflict Minerals in the Democratic Republic of the Congo.” SIPRI Policy Paper 27. Stockholm: Stockholm International Peace Research Institute. Available at: http://books.sipri.org/files/PP/SIPRIPP27.pdf (accessed on June 8, 2012).

Dupas, Pascaline. 2009. “What Matters (and What Does Not) in Households’ Decision to Invest in Malaria Prevention?” *American Economic Review* 99(2): 224–30.

Dupas, Pascaline. 2014. “Short-Run Subsidies and Long-Run Adoption of New Health Products: Evidence from a Field Experiment.” *Econometrica* 82(1): 197–228.

Edwards, Ryan B. 2016. “Mining Away the Preston Curve.” *World Development* 78: 22–36.

Fiorentini, Gianluca and Sam Peltzman (Eds). 1997. *The Economics of Organized Crime*. Cambridge: Cambridge University Press.

Funk, Chris C., Pete J. Peterson, Martin F. Landsfeld, Diego H. Pedreros, James P. Verdin, James D. Rowland, Bo E. Romero, Gregory J. Husak, Joel C. Michaelsen and Andrew P. Verdin. 2014. “A Quasi-global Precipitation Time Series for Drought Monitoring.” US Geological Survey Data Series 832, 4 p., http://dx.doi.org/10.3133/ds832 (accessed on August 22, 2016).

Geenen, Sara. 2012. “A Dangerous Bet: The Challenges of Formalizing Artisanal Mining in the Democratic Republic of Congo.” *Resources Policy* 37(3):322–330.

Geenen, Sara. 2016. *African Artisanal Mining from the Inside Out*. Routledge Press, New York, NY.

Gibbons, Elizabeth and Richard Garfield. 1999. “The Impact of Economic Sanctions on Health and Human Rights in Haiti, 1991–1994.” *American Journal of Public Health* 89: 1499–1504.

Guha-Sapir, Debarati and Olivia D’Aoust. 2010. “Demographic and Health Consequences of Civil Conflict.” World Development Report—Background Paper. Washington, DC: World Bank.

Guha-Sapir, Debarati, Willem G. van Panhuis, Olivia Degomme and Vicente Teran. 2005. “Civil Conflicts in Four African Countries: A Five-Year Review of Trends in Nutrition and Mortality.” *Epidemiologic Reviews* 27: 67–77.

Han, Peter J. and Jeremy D. Foltz. 2015. ‘The Effects of Weather Shocks on Child Survival in Mali’. Mimeo, University of Wisconsin-Madison.

Hafner-Burton, Emilie M. and Kiyoteru Tsutsui. 2005. “Human Rights in a Globalizing World: The Paradox of Empty Promises.” *American Journal of Sociology* 110(5): 1373–1411.

Hansen, Matthew C., PeterV. Potapov, Matthew Hancher, Svetlana A. Turubanova, Alexandra Tyukavina, David Thau, Stephen V. Stehman, Scott J. Goetz, Thomas R. Loveland, Anil Kommareddy, Alexey Egorov, Louise Chini, Christopher O. Justice and John R.G. Townshend. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science* 342(6160): 850–53.

Haufler, Virginia. 2009. “The Kimberley Process Certification Scheme: An Innovation in Global Governance and Conflict Prevention.” *Journal of Business Ethics* 89(4): 403-416.

Hufbauer, Gary C., Jeffrey J. Schott, Kimberly A. Elliot and Barbara Oegg. 2009. *Economic Sanctions Reconsidered, 3rd Edition*. Washington, DC: Peterson Institute for International Economics.

Jameson, N. Jordan., Xin Song and Michael Pecht. 2015. “Conflict Minerals in Electronic Systems: An Overview and Critique of Legal Initiatives.” *Science and Engineering Ethics*, 22(89): 1-15.

Johnson, Dominic. 2013. “No Kivu, No Conflict? The Misguided Struggle against ‘Conflict Minerals’ in the DRC.” Available at: http://nanojv.files.wordpress.com/2013/05/etude-sur-les-mines-du-kivu.pdf, visited June 16, 2014.

Killeen, Gerry F., Tom A. Smith, Heather M. Ferguson, Hassan Mshinda, Salim Abdulla, Christian Lengeler and Steven P. Kachur. 2007. “Preventing Childhood Malaria in Africa by Protecting Adults from Mosquitoes With Insecticide-Treated Nets.” *PLoS Medicine* 4(7): 1246–57.

Koppensteiner, Martin F. and Marco Manacorda. 2016. “Violence and Birth Outcomes: Evidence from Homicides in Brazil.” *Journal of Development Economics* 119: 16–33.

Kotsadam, Andreas and Anja Tolonen. 2016. “African Mining, Gender, and Local Employment.” *World Development* 83: 325–39.

Kudamatsu, Masayuki, Torsten Persson and David Strömberg. 2012. “Weather and Infant Mortality in Africa.” CEPR Discussion Paper No. 9222. London: Centre for Economic Policy Research.

Lezhnev, Sasha and John Prendergast. 2009. “From Mine to Mobile Phone: The Conflict Minerals Supply Chain. Appendix A: What Should be Done about Congo’s Gold Trade? Enough Project.” Available at: www.enoughproject.org/publications/mine-mobile-phone?page=8 (accessed on June 8, 2012).

Loayza, Norman, Alfredo Mier y Teran and Jamele Rigolini. 2013. “Poverty, Inequality, and the Local Natural Resource Curse.” Technical Report, World Bank, Washington, DC

Mampilly, Zachariah C. 2011. *Rebel Rulers: Insurgent Governance and Civilian Life during War*. Cornell University Press: Ithaca New York.

Mansour, Hani and Daniel I. Rees. 2012. “Armed Conflict and Birth Weight: Evidence from the al-Aqsa Intifada.” *Journal of Development Economics* 99: 190–99.

Maystadt, Jean-Francios, Giacomo De Luca, Petros G. Sekeris and John Ulimwengu. 2014. “Mineral Resources and Conflicts in DRC: A Case of Ecological Fallacy?” *Oxford Economic Papers* 66(3): 721-749.

Minoiu, Camelia and Olga N. Shemyakina. 2014. “Armed Conflict, Household Victimization, and Child Health in Côte d´Ivoire.” *Journal of Development Economics* 108: 237–55.

Morduch, Jonathan. 2000. “Sibling Rivalry in Africa.” *American Economic Review* 90(2): 405–09.

Olsson, Ola. 2007. “Conflict Diamonds.” *Journal of Development Economics* 82:267-286.

Parker, Dominic P. and Bryan Vadheim. 2017. ‘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(11): 1-49.

Peksen, Dursun. 2011. “Economic Sanctions and Human Security: The Public Health Effect of Economic Sanctions.” *Foreign Policy Analysis* 7: 237–51.

Pellillo, Adam. 2012. “Conflict and Development: Evidence from the Democratic Republic of the Congo.” Working Paper. Available at: http://www.be.wvu.edu/econ_seminar/documents/11-12/pellillo.pdf (accessed 8 June 2012).

Pöyhönen, Päivi, Kristina A. Bjurling, and Jaroen Cuvelier. 2010. “Voices from the Inside: Local Views on Mining Reform in Eastern DR Congo.” Finnwatch and Swedwatch. Available at: http://goodelectronics.org/publications-en/Publication_3586 (accessed on June 8, 2012).

Radley, Ben and Christoph Vogel. 2015. “Fighting Windmills in the Eastern Congo. The Ambiguous Impact of the ‘Conflict Minerals’ Movement.” *The Extractive Industries and Society* 2(3): 406-410.

Raleigh, Clionadh, Andrew Linke, Håvard Hegre and Joakim Karlsen. 2010. “Introducing ACLED—Armed Conflict Location and Event Data.” *Journal of Peace Research* 47(5): 1–10.

Romero, Mauricio and Santiago Saavedra. 2015. “The Effect of Gold Mining on the Health of Newborns.” Mimeo. Stanford University.

Sánchez de la Sierra, Raúl. 2015a. “On the Origins of States: Stationary Bandits and Taxation in the Eastern Congo.” HiCN Working Paper 194. Brighton, UK: Institute of Development Studies.

Sánchez de la Sierra, Raúl. 2015b. "Dis-organizing Violence: On the Ends of the State, Stationary Bandits and the Time Horizon." Mimeo. UC-Berkeley.

Schraeder, David. 2011. "The World Gold Council Unveils Initiative to Combat 'Conflict Gold'." World Gold Council. Available at: http://www.gold.org/news-and-events/press-releases/world-gold-council-unveils-initiative-combat-%E2%80%98conflict-gold%E2%80%99 (accessed on May 5, 2015).

Seay, Laura E. 2012. "What's Wrong with Dodd-Frank 1502? Conflict Minerals, Civilian Livelihoods, and the Unintended Consequences of Western Advocacy." Center for Global Development Working Paper No. 284. Washington, DC: Center for Global Development.

Sematumba, Onesphore (Ed.) 2011. "DRC: The Mineral Curse." The Pole Institute. Available at: www.pole-institute.org/documents/RCn per centB030bis.pdf, (accessed on June 7, 2012).

Skepardas, Stergios. 2001. "The Political Economy of Organized Crime: Providing Protection When the State Does Not." *Economics of Governance* 2: 173-202.

Spittaels, Steven. 2010. "The Complexity of Resource Governance in a Context of State Fragility: An Analysis of the Mining Sector in the Kivu Hinterlands." Antwerp: International Peace Information Service. Available at: www.ipisresearch.be/fck/file/20101202KIVUGL.pdf (accessed on June 22, 2012).

Spittaels, Steven and Filip Hilgert. 2008. "Mapping Conflict Motives: Katanga." IPIS. Available at: www.ipisresearch.be/maps/Katanga_update3/20090105_Mapping_Katanga_Update3_ENG.pdf (accessed on June 22, 2012).

Spittaels, Steven and Filip Hilgert. 2009. "Accompanying Note on the Interactive Map of Militarised Mining Areas of the Kivus." Antwerp: International Peace Information Service. Available at: www.ipisresearch.be/maps/MiMiKi/20090807_MiningKivus.pdf (accessed on June 22, 2012).

Spittaels, Steven and Filip Hilgert. 2010. "Mapping Conflict Motives: Province Oriental. (DRC)." IPIS. Available at: www.ipisresearch.be/maps/Orientale/20100322_MappingOrientale.pdf (accessed on June 22, 2012).

Stearns, Jason K. 2014. "Causality and Conflict: Tracing the Origins of Armed Groups in the Eastern Congo." *Peacebuilding* 2(2): 157-171.

Tolonen, Anja K. 2014. "Local Industrial Shocks, Female Empowerment and Infant Health: Evidence from Africa's Gold Mining Industry." Mimeo. University of Gothenburg, Gothenburg.

Thomas, Duncan, John Strauss and Maria-Helena Henriques. 1990. "Child Survival, Height for Age and Household Characteristics in Brazil." *Journal of Development Economics*, 33(2): 197–234.

UNICEF. 2013. “Levels and Trends in Child Mortality, Report 2013:Estimates Developed by the UN Inter agency Group for Child Mortality Estimation.” New York, NY: UNICEF.

United Nations Security Council. 2014. “Final Report of the Group of Exports on the Democratic Republic of the Congo.” Available at: www.un.org/sc/committees/1533/egroup.shtml (accessed on May 5, 2015).

United States Department of the Treasury, Office of Foreign Asset Control. 2016. Home Page. Available at: https://www.treasury.gov/resource-center/sanctions/Pages/default.aspx (accessed on June 10, 2016).

United States Department of State. 2011. “Democratic Republic of the Congo Mineral Exploitation by Armed Groups and Other Entities.” Available at: https://hiu.state.gov/Products/DRC_MineralExploitation_2011June14_HIU_U357.pdf. (accessed on August 22, 2016).

United States Geological Services. 2008-2012. Mineral Yearbooks Reports: available online at http://minerals.usgs.gov/minerals/pubs/country/2012/myb3-2012-cg.pdf. (accessed on May 5, 2015).

von der Goltz, Jan and Prabhat Barnwal. 2014. “Mines: The Local Welfare Effects of Mines in Developing Countries.” Columbia University, Department of Economics Discussion Paper No. 1314–19. New York, NY: Columbia University.

van der Ploeg, Frederick. 2011. “Natural Resources: Curse or Blessing?” *Journal of Economic Literature* 49(2): 366–420.

Wimmer, Sarah Z. and Filip Hilgert. 2011. “Bisie: A One-Year Snapshot of the DRC’s Principal Cassiterite Mine.” Antwerp: International Peace Information Service. Available at: http://www.ipisresearch.be/publications_detail.php?id=345 (accessed on June 20, 2012).

Woody, Karen E. 2012. “Conflict Minerals Legislation: The SEC’s New Role as Diplomatic and Humanitarian Watchdog.” *Fordham Law Review* 81(101): 1315-1351.

Wooldridge, Jeffrey M. 2002. “Discrete Response Models.” Chapter 15 in *Econometric Analysis of Cross Section and Panel Data*. MIT Press, Cambridge Massachusetts: 453-516.

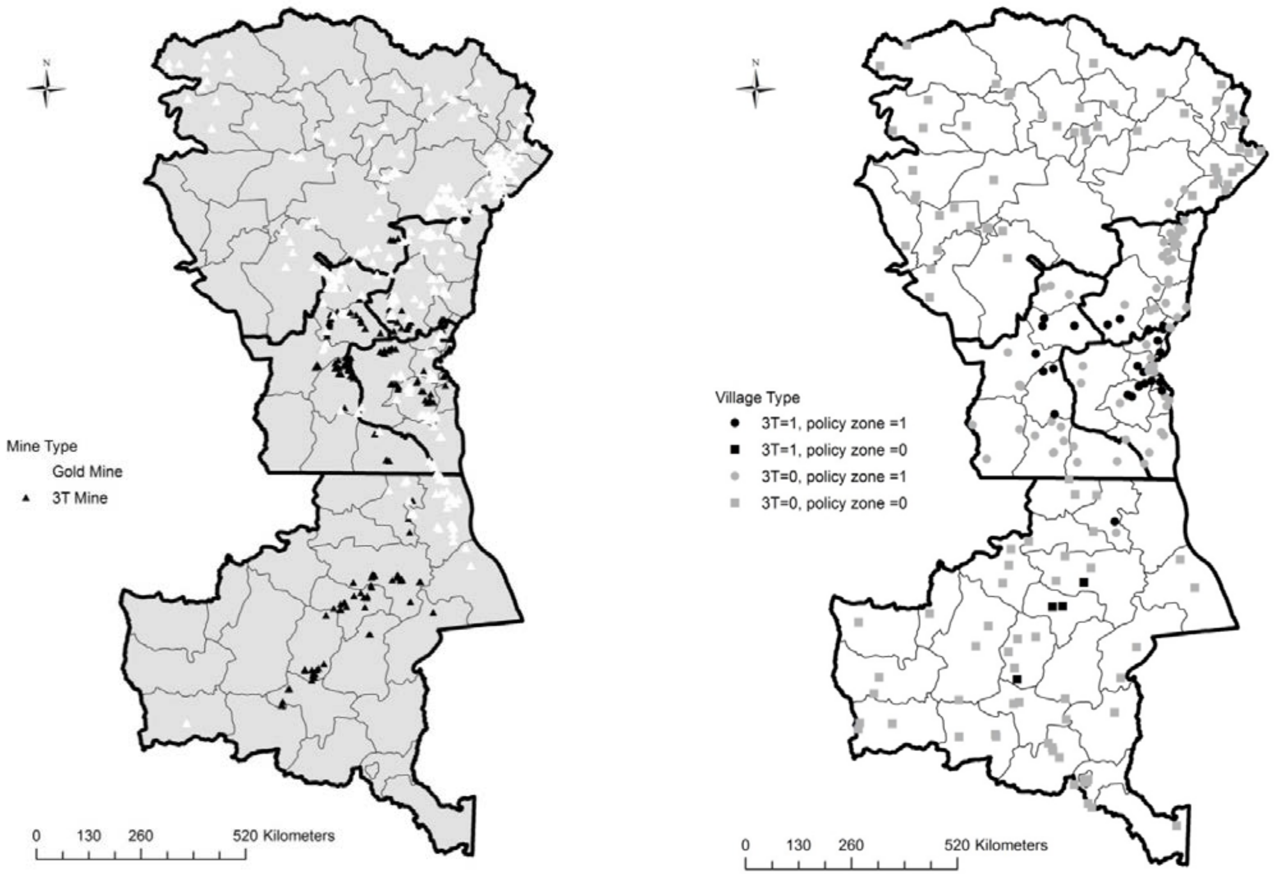
World Bank. 2008. “Democratic Republic of Congo Growth with Governance in the Mining Sector.” Report No. 43402-ZR. Available at: www.congomines.org/wp-content/uploads/2011/10/BanqueMondiale-2008-GrowthWithGovernance.pdf. (accessed on June 19, 2012).

Zaidi, Sarah and Mary C. Smith Fawzi. 1995. ‘Health of Baghdad’s Children.” *The Lancet*, 346(Dec. 2): 1485.

**Figure 1: Study Area (the Provinces of the Eastern DRC)**


**Notes:** The provinces of the eastern DRC are Katanga, Maniema, South Kivu, North Kivu, and Orientale. The shapefiles for province boundaries come from www.gadm.org/about.

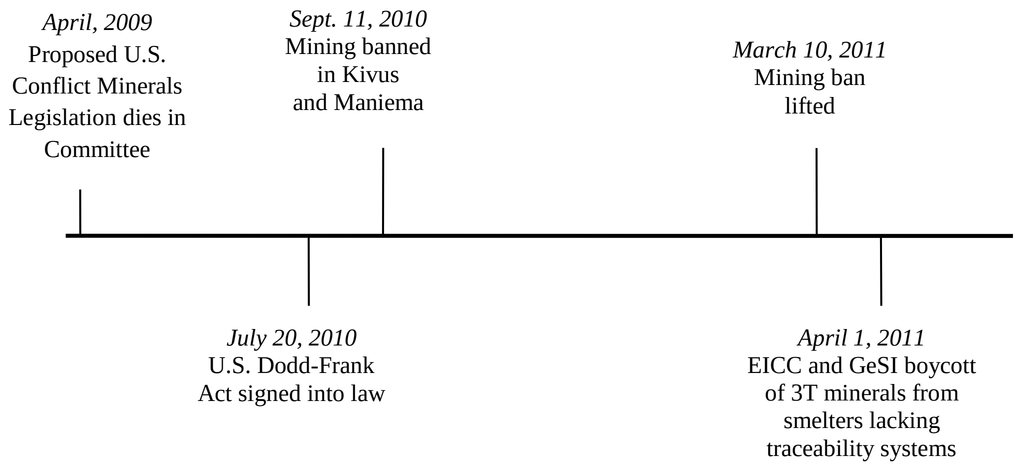
**Figure 2: IPIS Mines and DHS Villages in the Eastern DRC**




**Notes:** The dark colored lines outline the provinces of Katanga, Maniema, South Kivu, North Kivu, and Orientale. The light lines outline the 70 territories in these five provinces. The "Policy Zone" comprises the union of villages in provinces where mining was banned (i.e. Maniema, North Kivu, and South Kivu) and those with geo-coordinates falling within the U.S. State Department's Section 1502 map of conflict mining zones. The map is available at: https://hiu.state.gov/Products/DRC_MineralExploitation_2011June14_HIU_U357.pdf.

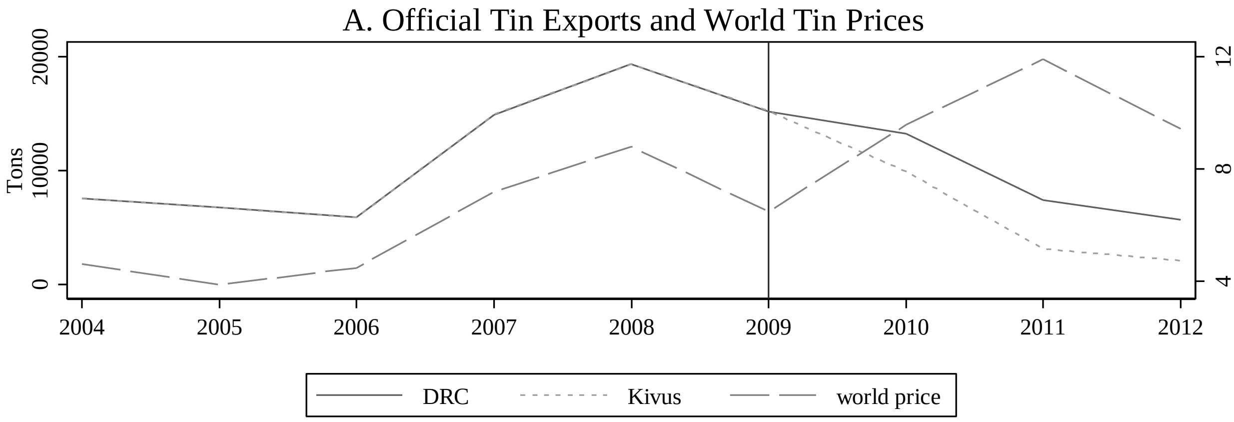
Source: The shapefiles on territory boundaries come from www.gadm.org/about. The geocoordinates of mining locations come from Spitaels and Hilgert (2008), Spittaels and Hilgert (2009), Spittaels (2010), and Spittaels and Hilgert (2010). The geocoordinates of villages come from the Demographic Health Survey data.

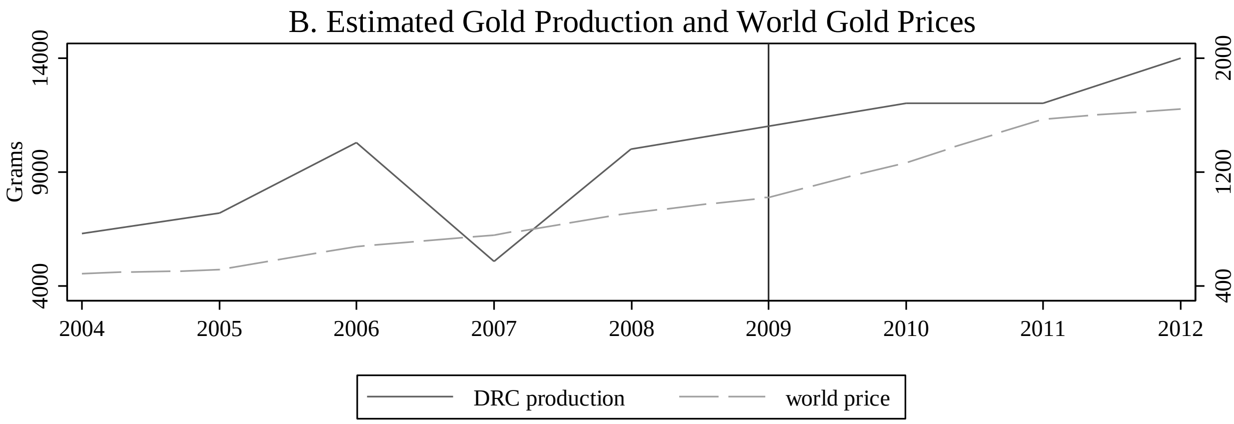
## Figure 3: Timeline of Key Regulations




Source: Authors' illustration of events described in text.

## Figure 4: Mineral Exports and Production

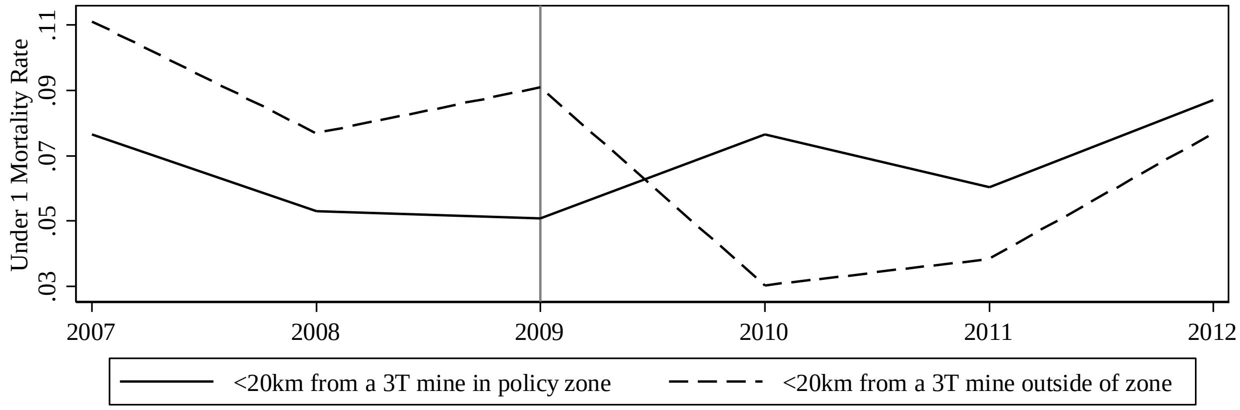



**Notes:** The vertical line at 2009 signifies the final year prior to the conflict mineral policies. The axis on the left side indicates the official exports of tin, in tons, from the DRC. All of the exports were sent from North and South Kivu (the "Kivus") prior to 2010. After 2009, some of the exports were sent from Katanga. The difference between the Kivus and DRC lines indicates the tons exported from Katanga. The world price of tin, per pound, is shown on the right-hand side axis. The tin price is the monthly average of the cash official price paid by buyers on the London Market Exchange, in 2012 U.S. dollars per ton. The gold price represents the monthly average of the PM spot prices on the London Market Exchange, in 2012 U.S. dollars per gram.

Source: Authors' calculations based on data from USGS Mineral Yearbooks Reports, 2008–12, available online at http://minerals.usgs.gov/minerals/pubs/country/2012/myb3-2012-cg.pdf.

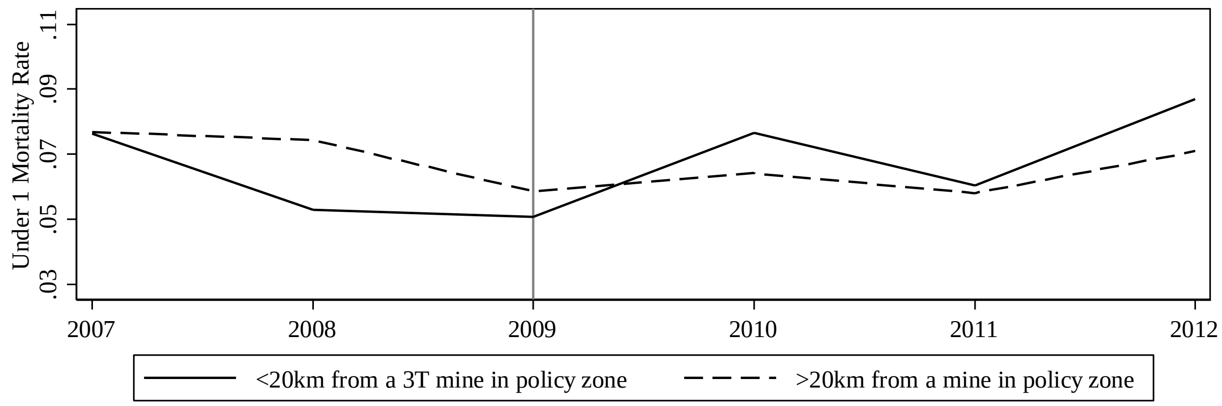
**Figure 5: Mean Mortality Rates across DHS Villages that are within 20km of a 3T Mine, Inside versus Outside the Policy Zone**




**Notes:** The vertical line at 2009 signifies the final year prior to the conflict mineral policies. There were 1,152 births in DHS villages within 20 km of a 3T mine during 2007-2012. Of these births, 992 were spread across 23 DHS villages inside the policy zone and 160 were spread across 4 DHS villages outside the policy zone.

Source: Authors calculations from DHS data.

**Figure 6: Mean Mortality Rates across DHS Villages in the Policy Zone, Near versus Distant to 3T Mines**




**Notes:** The vertical line at 2009 signifies the final year prior to the conflict mineral policies. There were 3,499 births in DHS villages within the policy zone during 2007-2012. Of these births, 992 were spread across 23 DHS villages within 20 km of a 3T mine and 2,507 were spread across 67 DHS villages farther than 20 km from a 3T mine.

Source: Authors calculations from DHS data.

## Table 1: Summary Statistics

| | Mean | St. Dev | Min | Max | Description |
|---|---|---|---|---|---|
| Under 1 Mortality[a] | 0.072 | 0.259 | 0 | 1 | =1 if child died within first 12 months of life, 0 otherwise |
| Policy Zone[b] | 0.454 | 0.498 | 0 | 1 | =1 if DHS village is in policy zone (see figure 2), otherwise = 0 |
| 3Ts [c] | 0.657 | 1.992 | 0 | 11 | # of Cassiterite, Coltan, and Wolframite mines within 20 km of DHS village |
| 3T Indicator[c] | 0.149 | 0.357 | 0 | 1 | = 1 if 3T 20 km is nonzero, 0 otherwise |
| Gold[c] | 1.138 | 2.944 | 0 | 22 | # of Gold mines within 20 km of DHS villages |
| Gold Indicator[c] | 0.311 | 0.462 | 0 | 1 | = 1 if Gold 20 km is nonzero, 0 otherwise |
| Post DF | 0.433 | 0.463 | 0 | 1 | = Proportion of 12 months post-birth during which Dodd Frank was law |
| Post DF *x* 3T Indicator[c] | 0.078 | 0.269 | 0 | 1 | Interaction of variables defined above |
| Post DF *x* Gold Indicator [c] | 0.164 | 0.370 | 0 | 1 | Interaction of variables defined above |
| Post DF *x* 3T Ind *x* Policy Zone | 0.068 | 0.252 | 0 | 1 | Interaction of variables defined above |
| Post DF *x* Gold Ind *x* Policy Zone | 0.096 | 0.296 | 0 | 1 | Interaction of variables defined above |
| Rain after birth[d] | 0.094 | 0.969 | -2.04 | 4.50 | Standardized average of rainfall 3 months before birth |
| Rain before birth[d] | 0.104 | 0.978 | -2.04 | 4.02 | Standardized average of rainfall 3 months after birth |
| Wet Season[d] | 0.255 | 0.435 | 0 | 1 | =1 if birth is in 3 wettest months in each territory, based on 1982-2013 |
| Dry Season[d] | 0.256 | 0.436 | 0 | 1 | =1 if birth is in driest months in each territory, based on 1982-2013 |
| Birth Order[a] | 1.948 | 0.904 | 1 | 7 | Birth order, lower indicates younger |
| Male | 0.493 | 0.499 | 0 | 1 | =1 1 if child is male, otherwise =0 |
| Household Size[a] | 7.102 | 3.088 | 1 | 24 | Household size at time of interview |
| Years of Education[a] | 4.179 | 3.667 | 0 | 18 | Years of education of mother |
| Married[a] | 0.864 | 0.342 | 0 | 1 | =1 if mother is married or living with partner, otherwise =0 |
| Literate[a] | 0.469 | 0.499 | 0 | 1 | =1 if mother is literate, otherwise =0 |
| Observations | 7,697 | | | | |

Authors' calculations based on (a) DHS 2013–14 data set; (b) US State Department (2011); (c) interactive maps described in Spitaels and Hilgert (2008), Spittaels and Hilgert (2009), Spittaels (2010), and Spittaels and Hilgert (2010); and (d) Climatic Research Unit (2015).

**Table 2:**
**Linear Fixed Effects Estimates of Under-1 Mortality**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Post DF x Policy Zone ( $\beta_1$) | -0.021 | -0.034$^{*}$ | 0.004 | -0.006 | -0.038 | -0.020 |
| | (0.014) | (0.017) | (0.029) | (0.036) | (0.027) | (0.032) |
| Post DF *x* 3T Indicator ( $\beta_2$) | -0.060 | -0.090$^{***}$ | -0.064 | -0.086$^{***}$ | -0.136$^{***}$ | -0.121$^{***}$ |
| | (0.043) | (0.027) | (0.044) | (0.027) | (0.031) | (0.038) |
| **Treatment Effect ( $\beta_3$)** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.086**$^{*}$ | **0.116**$^{***}$ | **0.095**$^{*}$ | **0.119**$^{***}$ | **0.182**$^{***}$ | **0.143**$^{***}$ |
| | **(0.048)** | **(0.035)** | **(0.049)** | **(0.034)** | **(0.039)** | **(0.044)** |
| Post DF *x* Gold Indicator ( $\beta_4$) | 0.002 | -0.017 | 0.006 | -0.028 | 0.010 | -0.026 |
| | (0.018) | (0.018) | (0.024) | (0.026) | (0.023) | (0.034) |
| Post DF *x* Gold Ind *x* Policy ( $\beta_5$) | -0.000 | 0.017 | -0.002 | 0.035 | -0.033 | -0.004 |
| | (0.026) | (0.026) | (0.030) | (0.031) | (0.031) | (0.039) |
| Covariates | | | | | | |
| Precip. after birth | 0.007 | 0.016$^{***}$ | 0.008$^{*}$ | 0.016$^{***}$ | 0.007 | 0.018$^{***}$ |
| Precip. before birth | -0.010$^{**}$ | -0.013$^{**}$ | -0.009$^{*}$ | -0.015$^{**}$ | -0.008$^{*}$ | -0.012$^{*}$ |
| Wet Season | 0.005 | 0.016 | 0.005 | 0.018 | 0.003 | 0.011 |
| Dry Season | -0.000 | -0.004 | 0.000 | -0.008 | 0.004 | -0.001 |
| Birth Order | 0.036$^{***}$ | 0.026$^{*}$ | 0.036$^{***}$ | 0.024 | 0.037$^{***}$ | 0.031$^{**}$ |
| Male | 0.020$^{***}$ | 0.027$^{***}$ | 0.020$^{***}$ | 0.026$^{***}$ | 0.019$^{***}$ | 0.026$^{***}$ |
| Household Size | -0.006$^{***}$ | 0.000 | -0.006$^{***}$ | 0.000 | -0.006$^{***}$ | 0.000 |
| Years of Education | 0.001 | | 0.001 | | 0.001 | |
| Married | -0.031$^{***}$ | | -0.031$^{***}$ | | -0.031$^{***}$ | |
| Literate | -0.008 | | -0.009 | | -0.008 | |
| Village fixed effects | Yes | No | Yes | No | Yes | No |
| Mother fixed effects | No | Yes | No | Yes | No | Yes |
| Month of birth fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Area-wide year fixed effects | Yes | Yes | No | No | Yes | Yes |
| Province specific year effects | No | No | Yes | Yes | No | No |
| Territory specific linear trends | No | No | No | No | Yes | Yes |
| Observations | 7697 | 7697 | 7697 | 7697 | 7697 | 7697 |
| $R^2$ (within) | 0.019 | 0.016 | 0.022 | 0.024 | 0.033 | 0.042 |

**Notes**: Standard errors in parentheses, clustered by DHS village. $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table 3:**
**Robustness Checks of Mortality Estimates**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| ***1. Baseline*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.086**$^{*}$ | **0.116**$^{***}$ | **0.095**$^{*}$ | **0.119**$^{***}$ | **0.182**$^{***}$ | **0.143**$^{***}$ |
| Post DF *x* Gold Ind *x* Policy Zone | -0.000 | 0.017 | -0.002 | 0.035 | -0.033 | -0.004 |
| Observations | 7697 | 7697 | 7697 | 7697 | 7697 | 7697 |
| $R^2$ (within) | 0.019 | 0.016 | 0.022 | 0.024 | 0.033 | 0.042 |
| ***2. Interact with Number of Mines*** | | | | | | |
| **Post DF *x* 3Ts *x* Policy Zone** | **0.016**$^{***}$ | **0.021**$^{***}$ | **0.017**$^{***}$ | **0.022**$^{***}$ | **0.027**$^{***}$ | **0.021**$^{***}$ |
| Post DF *x* Gold *x* Policy Zone | 0.003 | 0.009$^{*}$ | 0.003 | 0.009$^{*}$ | 0.000 | 0.008 |
| Observations | 7697 | 7697 | 7697 | 7697 | 7697 | 7697 |
| $R^2$ (within) | 0.020 | 0.018 | 0.023 | 0.025 | 0.033 | 0.041 |
| ***3. Omits 2010*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.089**$^{*}$ | **0.083**$^{**}$ | **0.098**$^{*}$ | **0.080**$^{*}$ | **0.223**$^{***}$ | **0.152**$^{***}$ |
| Post DF *x* Gold Ind *x* Policy Zone | 0.006 | 0.026 | 0.011 | 0.052 | -0.022 | 0.025 |
| Observations | 6314 | 6314 | 6314 | 6314 | 6314 | 6314 |
| $R^2$ (within) | 0.018 | 0.018 | 0.022 | 0.027 | 0.036 | 0.055 |
| ***4. SE Clusters at Territory*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.086** | **0.116**$^{***}$ | **0.095** | **0.119**$^{***}$ | **0.182**$^{***}$ | **0.143**$^{***}$ |
| Post DF *x* Gold Ind *x* Policy Zone | -0.000 | 0.017 | -0.002 | 0.035 | -0.033 | -0.004 |
| Observations | 7697 | 7697 | 7697 | 7697 | 7697 | 7697 |
| $R^2$ (within) | 0.016 | 0.014 | 0.019 | 0.022 | 0.074 | 0.128 |
| ***4. SE Clusters at 3T Mine Level*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.086** | **0.116**$^{***}$ | **0.095**$^{*}$ | **0.119**$^{***}$ | **0.182**$^{***}$ | **0.143**$^{***}$ |
| Post DF *x* Gold Ind *x* Policy Zone | -0.000 | 0.017 | -0.002 | 0.035 | -0.033 | -0.004 |
| Observations | 7697 | 7697 | 7697 | 7697 | 7697 | 7697 |
| $R^2$ (within) | 0.016 | 0.014 | 0.019 | 0.022 | 0.074 | 0.128 |
| Precipitation controls | Yes | Yes | Yes | Yes | Yes | Yes |
| DHS controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Mother fixed effects | No | Yes | No | Yes | No | Yes |
| Village fixed effects | Yes | No | Yes | No | Yes | No |
| Month of birth fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Area wide year fixed effects | Yes | Yes | No | No | Yes | Yes |
| Province specific year effects | No | No | Yes | Yes | No | No |
| Territory specific linear trends | No | No | No | No | Yes | Yes |

**Notes**: $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$. Standard errors are clustered by DHS village unless otherwise noted. All specifications follow the same sequencing of covariate use shown in table 2. Panel 1 shows the benchmark results from the previous table. Panel 2 interacts the post-2009 indicators with the number of mines within a 20km radius, rather than with an indicator for the presence of at least one mine as in the baseline. Panel 3 drops observations from 2010, the year in which Dodd Frank and the mining ban policies were passed. Panel 4 clusters the standard errors at the territory. Panel 5 clusters the errors at the 3T mine level, so that villages within 20km of the same 3T mine are combined into a cluster group.

**Table 4:**
**Mortality Estimates with Different Radius Lengths**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| ***1. Baseline Results (20 km)*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.086***$^{*}$ | **0.116***$^{***}$ | **0.095***$^{*}$ | **0.119***$^{***}$ | **0.182***$^{***}$ | **0.143***$^{***}$ |
| Post DF *x* Gold Ind *x* Policy Zone | -0.000 | 0.017 | -0.002 | 0.035 | -0.033 | -0.004 |
| $R^2$ (within) | 0.019 | 0.016 | 0.022 | 0.024 | 0.033 | 0.042 |
| ***2. 10 km radius*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.144**$^{***}$ | **0.127**$^{***}$ | **0.151**$^{***}$ | **0.124**$^{***}$ | **0.198**$^{***}$ | **0.167**$^{***}$ |
| Post DF *x* Gold Ind *x* Policy Zone | 0.029 | 0.064$^{**}$ | 0.024 | 0.070$^{**}$ | -0.006 | 0.024 |
| $R^2$ (within) | 0.020 | 0.017 | 0.023 | 0.024 | 0.033 | 0.042 |
| ***3. 30 km radius*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.082**$^{**}$ | **0.108**$^{***}$ | **0.089**$^{**}$ | **0.109**$^{***}$ | **0.161**$^{***}$ | **0.133**$^{***}$ |
| Post DF *x* Gold Ind *x* Policy Zone | -0.015 | -0.025 | -0.017 | -0.008 | -0.055$^{*}$ | -0.046 |
| $R^2$ (within) | 0.020 | 0.017 | 0.023 | 0.024 | 0.034 | 0.042 |
| ***4. 40 km radius*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.023** | **0.045** | **0.038** | **0.061**$^{*}$ | **0.088**$^{**}$ | **0.080** |
| Post DF *x* Gold Ind *x* Policy Zone | -0.000 | -0.019 | -0.001 | -0.009 | -0.053$^{*}$ | -0.052 |
| $R^2$ (within) | 0.020 | 0.016 | 0.023 | 0.025 | 0.033 | 0.042 |
| ***5. 50 km radius*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.013** | **0.040** | **0.021** | **0.045** | **0.070**$^{*}$ | **0.069** |
| Post DF *x* Gold Ind *x* Policy Zone | 0.001 | -0.009 | -0.001 | 0.006 | -0.064$^{**}$ | -0.047 |
| $R^2$ (within) | 0.020 | 0.016 | 0.023 | 0.025 | 0.034 | 0.042 |
| Precipitation controls | Yes | Yes | Yes | Yes | Yes | Yes |
| DHS controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Mother fixed effects | No | Yes | No | Yes | No | Yes |
| Village fixed effects | Yes | No | Yes | No | Yes | No |
| Month of birth fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Area wide year fixed effects | Yes | Yes | No | No | Yes | Yes |
| Province specific year effects | No | No | Yes | Yes | No | No |
| Territory specific linear trends | No | No | No | No | Yes | Yes |

**Notes**: $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$. Standard errors are clustered by DHS village unless otherwise noted. All specifications follow the same sequencing of covariate use shown in table 2. All regressions employ 7,697 observations.

**Table 5:**
**Mortality Estimates with Controls for ACLED Conflict <20km from Villages**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| ***1. Baseline (No conflict controls)*** | | | | | | |
| **Post DF *x* 3T Ind *x* Policy Zone** | **0.086$^{*}$** | **0.116$^{***}$** | **0.095$^{*}$** | **0.119$^{***}$** | **0.182$^{***}$** | **0.143$^{***}$** |
| Post DF *x* Gold Ind *x* Policy Zone | -0.000 | 0.017 | -0.002 | 0.035 | -0.033 | -0.004 |
| $R^2$ (within) | 0.019 | 0.016 | 0.022 | 0.024 | 0.033 | 0.042 |
| ***2. All ACLED Conflicts*** | | | | | | |
| **Post DF *x* 3Ts *x* Policy Zone** | **0.088$^{*}$** | **0.116$^{***}$** | **0.096$^{*}$** | **0.119$^{***}$** | **0.187$^{***}$** | **0.146$^{***}$** |
| Post DF *x* Gold *x* Policy Zone | 0.001 | 0.017 | 0.001 | 0.036 | -0.031 | -0.004 |
| # of Conflict events | 0.000 | 0.000 | 0.000$^{*}$ | 0.000 | 0.001$^{**}$ | 0.000 |
| $R^2$ (within) | 0.019 | 0.016 | 0.022 | 0.024 | 0.034 | 0.042 |
| ***3. ACLED Conflicts by Type*** | | | | | | |
| **Post DF *x* 3Ts *x* Policy Zone** | **0.086$^{*}$** | **0.116$^{***}$** | **0.093$^{*}$** | **0.118$^{***}$** | **0.185$^{***}$** | **0.145$^{***}$** |
| Post DF *x* Gold *x* Policy Zone | 0.000 | 0.017 | -0.001 | 0.035 | -0.030 | -0.003 |
| # of Battle events | 0.002$^{**}$ | 0.001 | 0.001$^{**}$ | 0.001 | 0.002$^{**}$ | 0.001 |
| # of Violence vs. Civilian event | -0.001 | -0.001 | -0.001 | -0.000 | -0.000 | -0.001 |
| $R^2$ (within) | 0.020 | 0.017 | 0.022 | 0.024 | 0.034 | 0.042 |
| ***4. All ACLED Conflicts*** | | | | | | |
| **Post DF *x* 3Ts *x* Policy Zone** | **0.084$^{*}$** | **0.116$^{***}$** | **0.092$^{*}$** | **0.119$^{***}$** | **0.178$^{***}$** | **0.144$^{***}$** |
| Post DF *x* Gold *x* Policy Zone | 0.002 | 0.017 | 0.000 | 0.034 | -0.031 | -0.005 |
| Indicator of Conflict event | -0.012 | 0.002 | -0.012 | 0.002 | -0.011 | 0.002 |
| $R^2$ (within) | 0.019 | 0.016 | 0.022 | 0.024 | 0.033 | 0.042 |
| ***5. ACLED Conflicts by Type*** | | | | | | |
| **Post DF *x* 3Ts *x* Policy Zone** | **0.083$^{*}$** | **0.110$^{***}$** | **0.091$^{*}$** | **0.111$^{***}$** | **0.179$^{***}$** | **0.135$^{***}$** |
| Post DF *x* Gold *x* Policy Zone | 0.000 | 0.017 | -0.002 | 0.034 | -0.032 | -0.005 |
| Indicator of Battle event | -0.011 | -0.020 | -0.012 | -0.020 | -0.008 | -0.019 |
| Indicator of Violence vs. Civilian event | 0.006 | 0.022 | 0.010 | 0.029$^{*}$ | -0.000 | 0.022 |
| $R^2$ (within) | 0.019 | 0.017 | 0.022 | 0.026 | 0.033 | 0.043 |
| Precipitation controls | Yes | Yes | Yes | Yes | Yes | Yes |
| DHS controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Mother fixed effects | No | Yes | No | Yes | No | Yes |
| Village fixed effects | Yes | No | Yes | No | Yes | No |
| Month of birth fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Area wide year fixed effects | Yes | Yes | No | No | Yes | Yes |
| Province specific year effects | No | No | Yes | Yes | No | No |
| Territory specific linear trends | No | No | No | No | Yes | Yes |

**Notes**: $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$. Standard errors are clustered by DHS village unless otherwise noted. All specifications follow the same sequencing of covariate use shown in table 2. All regressions employ 7,697 observations.

**Table 6:**
**Linear Probability Estimates of Health Care Consumption**

| | Bednet (1) | Pre Natal Care (2) | Bednet (3) | PreNatal Care (4) |
|---|---|---|---|---|
| 3T Indicator ($\lambda_1$) | -0.308*** | -0.106 | -0.310*** | -0.094 |
| | (0.058) | (0.097) | (0.063) | (0.099) |
| 2013 *x* 3T Indicator ($\lambda_2$) | 0.198** | 0.234** | 0.200** | 0.222** |
| | (0.076) | (0.096) | (0.080) | (0.100) |
| 2013 *x* Policy Zone ($\lambda_3$) | -0.131 | 0.161** | 0.084 | -0.317* |
| | (0.091) | (0.074) | (0.089) | (0.187) |
| **Treatment Effect ($\lambda_4$)** | **-0.164** | **-0.200*** | **-0.182**** | **-0.188*** |
| **Post DF *x* 3T Ind x Policy Zone** | **(0.101)** | **(0.113)** | **(0.085)** | **(0.107)** |
| Gold Indicator ($\omega_1$) | -0.066 | -0.102 | -0.059 | -0.197 |
| | (0.095) | (0.096) | (0.102) | (0.131) |
| 2013 *x* Gold Indicator ($\omega_2$) | -0.052 | 0.141 | -0.058 | 0.236* |
| | (0.091) | (0.090) | (0.100) | (0.128) |
| Post DF *x* Gold Ind *x* Policy Zone ($\omega_3$) | 0.240** | -0.124 | 0.213* | -0.132 |
| | (0.112) | (0.106) | (0.116) | (0.139) |
| <u>Covariates (mother level)</u> | | | | |
| Urban | 0.104*** | 0.078*** | 0.103*** | 0.080*** |
| Years of Education | 0.002** | 0.003* | 0.002*** | 0.003** |
| Household Size | -0.004 | 0.001 | -0.005* | 0.002 |
| Married | 0.079*** | 0.022 | 0.080*** | 0.024* |
| Literate | 0.044*** | 0.026* | 0.043*** | 0.026* |
| Age | -0.002** | -0.002*** | -0.002** | -0.002*** |
| Territory fixed effects | Yes | Yes | Yes | Yes |
| Area wide 2013 time effects | Yes | Yes | No | No |
| Province x 2013 time effects | Yes | Yes | Yes | Yes |
| Territory x 2013 time effects | No | No | No | No |
| Observations | 7794 | 4393 | 7751 | 4386 |
| $R^2$ | 0.247 | 0.202 | 0.248 | 0.203 |

**Notes:** * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered by DHS village unless otherwise noted.

**Table 7:**
**Mortality Estimates with Heterogeneous Policy Effects, due to Armed Group Presence**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| ***1. Baseline (panel 2 of table 3)*** | | | | | | |
| Post DF *x* 3T Ind *x* Policy Zone | 0.016*** | 0.021*** | 0.017*** | 0.022*** | 0.027*** | 0.021*** |
| $R^2$ (within) | 0.020 | 0.018 | 0.023 | 0.025 | 0.033 | 0.041 |
| ***2. Armed Group Interactions*** | | | | | | |
| Post DF *x* 3Ts w AG *x* Policy Zone | 0.021** | 0.026*** | 0.037*** | 0.021*** | 0.028*** | 0.029*** |
| Post DF *x* 3Ts w/o AG *x* Policy Zone | 0.013** | 0.012** | 0.018*** | 0.022*** | 0.018*** | 0.012 |
| $R^2$ (within) | 0.020 | 0.023 | 0.032 | 0.018 | 0.026 | 0.040 |
| ***3. Armed Group Interactions by Type*** | | | | | | |
| Post DF *x* 3Ts Rebel AG *x* Policy Zone | 0.034 | 0.041** | 0.042** | 0.023 | 0.032** | 0.039* |
| Post DF *x* 3Ts Govt AG *x* Policy Zone | 0.017* | 0.023** | 0.036*** | 0.020** | 0.027*** | 0.027*** |
| Post DF *x* 3Ts w/o AG *x* Policy Zone | 0.013** | 0.012** | 0.018*** | 0.022*** | 0.018*** | 0.012 |
| $R^2$ (within) | 0.020 | 0.023 | 0.032 | 0.018 | 0.026 | 0.040 |
| Gold mine controls (same as baseline) | Yes | Yes | Yes | Yes | Yes | Yes |
| Precipitation controls | Yes | Yes | Yes | Yes | Yes | Yes |
| DHS controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Mother fixed effects | No | Yes | No | Yes | No | Yes |
| Village fixed effects | Yes | No | Yes | No | Yes | No |
| Month of birth fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Area wide year fixed effects | Yes | Yes | No | No | Yes | Yes |
| Province specific year effects | No | No | Yes | Yes | No | No |
| Territory specific linear trends | No | No | No | No | Yes | Yes |

**Notes**: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered by DHS village unless otherwise noted. All specifications follow the same sequencing of covariate use shown in table 2. The number of observations in all specifications is 7697. The notation "AG" stands for "Armed Group." The rebel armed groups in the IPIS maps (see Spittaels and Hilgert 2009 and Spittaels 2010), include the Forces for the Liberation of Rwanda (FDLR), the Forces Républicaines Fédéralistes (FRF), and Mayi Mayi militias (an umbrella term for loosely affiliated groups of local militias). The government armed groups include the Armed Forces of the Democratic Republic of Congo (FARDC) and the National Congolese Police (PNC).