Ban it or Buy It?

The Unintended Consequences of Conflict Mineral Policies

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Abstract: There is widespread perception that trade in "conflict minerals" is causing violence in the Democratic Republic of Congo (DRC). Policy responses include the U.S. Dodd-Frank Act of 2010, which regulates companies whose products contain conflict minerals, and the DRC's ban on artisanal mining in three of its provinces during 2010-2011. We develop a simple theory to explain why these restrictions on trade in minerals could cause violence to increase in the DRC. The theory is inspired by Mancur Olson's (2000) *stationary bandit* metaphor, and suggests that the higher present value of mining sites prior to Dodd Frank caused armed groups to 'protect' miners and encourage steady long-run production. By lowering the value of certain mines, the policies caused the armed groups to behave like the more dangerous *roving bandit*, who has less stake in the future economic productivity of a mining area. We test the implication by merging geo-referenced datasets on armed conflict, militarized mining sites, and mineral prices. We find evidence that the policies increased the incidence of conflict in mining territories shortly after their enactment by about 57 percent.

1. Introduction

There are two commonly held beliefs about mineral rich lands in the Democratic Republic of Congo (DRC). The first is that these resources have been more of a curse than a blessing for Congolese citizens. This view is advanced by advocacy organizations, such as the Enough Project and Global Witness, which have been seeking to end the trade in "conflict minerals." Conflict minerals - tin, tantalum, tungsten and gold – end up in mobile phones, computers, and other electronic devices sold in world markets. Revenue from their trade, according to the advocacy organizations, is the incentive for armed conflict and the fuel for further violence because it finances illicit armed militia groups.

The second belief is that Congo's "resource curse" can be mitigated through top-down solutions that restrict trade in minerals extracted with armed group involvement. Proposals from the United Nations and advocacy groups have included embargos, boycotts and sanctions (Geenan 2012). The policies actually implemented were Section 1502 of the U.S. Dodd-Frank Act of 2010 and the DRC's recent ban on artisanal mining. Section 1502 requires large western companies to publicly report on the origin of their minerals. It has acted as an "intended or unintended boycott" on purchases of the tin, tantalum, and tungsten from the DRC (Pöyhönen et. al 2010, 27). The DRC ban on artisanal mining was for the purpose of weeding out "mafia-like groups" involved in the mining industry (see section 2). In effect from September 2010 through March 2011, it made illegal the extraction and export of minerals from three eastern provinces.

Because the policies dramatically reduced the value of mining sites to armed groups, they provide an outstanding setting for testing questions central to the study of natural resource curses. How does the level and nature of violent conflict change when the value of a fragile country's resource endowment sharply declines? How does conflict within the country change

when one of its resource commodities falls in value but another does not? The answers to these questions have important policy implications, of course, because international policies to ban or buy natural resources from conflict-ridden countries can have dramatic impacts on the value of endowments.

We study these questions by developing a simple theory of the short-run effects of the conflict mineral policies. We test our theory using geo-referenced data on militarized mining sites and armed civil conflict in the Eastern DRC before, during and after the policies. Our evidence indicates the policies back-fired and significantly increased conflict, at least over the short time interval we study. We join others in concluding that the resource curse is a complex phenomenon that is unlikely solved by simple actions to reduce the value of a country's natural resource endowments.[1]

Our approach with its focus on short-run effects complements others studies of how conflict interacts with resource endowment values in the longer run. That literature arguably contains a *credit view* and an *opportunity cost view* (see Janus 2011). The credit view is one in which conflicts are fought when they can be funded. It is a view usually associated with Collier and Hoeffler (2004), and it underlies the international community's emphasis on cutting off funding sources for armed groups through embargos, bans, and due diligence requirements. Recent empirical support for the credit view is provided by Angrist and Kugler (2008) who find a positive relationship between coca prices and violence in Columbian municipalities dependent on coca production.[2]

[1] Several recent studies cast doubt on the generalization that resource endowments are the cause of violence in conflict ridden countries. Miguel and Bellows (2009), for example, conclude that violence in Sierra Leone is held in check by the presence of diamonds. Bnrunnschweiler and Bulte (2009) revisit cross-country data on civil wars and resource endowments and find no systematic link between the two.

[2] Besley and Persson (2008) also find a positive relationship between world market prices of a country's main commodities and civil wars using a broad sample of countries.

According to the opportunity cost view, conflicts are more likely to occur when labor earns a low return if employed in non-conflict generating capacities.[3] Recent empirical support for the importance of opportunity cost is found in Dube and Vargas (2011) who also focus on Columbian civil conflict. Dube and Vargas find a positive relationship between oil prices and conflict in oil producing regions of Columbia, but a negative relationship between coffee prices and conflict in coffee producing regions. They argue that the opportunity cost effect dominates for labor intensive coffee production, but not for capital intensive oil production.[4]

Rather than modeling credit and opportunity cost, we deviate from the literature in order to focus on a short-run response to the policies, when warring capital is fixed, and to utilize detailed data on how mineral deposits are controlled by "mafia-like" armed groups.[5] Our thinking is inspired by Mancur Olson's theory of *stationary bandits* (Olson 2000). Stationary bandits are akin to Mafia families that tax production in neighborhoods they control. The Mafia maximizes its revenues by selling protection – both against crime it will commit itself (if not paid taxes) and against crime committed by others. Hence, if one Mafia family has the power to monopolize, there will be little to no ordinary crime. This low-crime equilibrium can break down if the Mafia anticipates future loss of monopoly power or it wishes to challenge another family for control over trade in a commodity. In the language of Olson, the stationary bandit will begin to behave like the more dangerous roving bandit, who has less stake in the future economic productivity of the neighborhood.

[3] Artisanal mining in the DRC is highly labor intensive, with almost no capital inputs, so a strong opportunity cost effect may be present in our setting.
[4] Similarily, Brückner and Ciccone (2010) find that decreases in a country's main commodity are associated with increases in the likelihood of civil war, which is consistent with a dominant opportunity cost effect.
[5] Our approach is more closely related to a recent paper on the relationship between conflict and mining in the DRC that conceives of conflict as being driven away from valuable mineral deposits (see De Luca et al. 2012).

Applying this analogy to the DRC, stationary bandits are militia groups and artisanal mining villages are neighborhoods. Prior to the embargo and ban, a single militia group typically taxed miners at regular intervals, which is consistent with stationary-bandit behavior (see section 3). The Olson metaphor suggests a low-violence equilibrium - with miners and militias sharing revenue - as long as militia monopoly power is not threatened. Dodd-Frank and the ban caused militia groups to more heavily discount the future value of mining sites and it changed the relative values of different sites, causing them to relocate their armed capital. The militias became roving bandits and this disrupted the low-violence equilibrium.

Our empirical findings and theoretical framework contribute to the policy debate about Section 1502 and the mining ban. Journalists and researchers working in the DRC accused the mining ban of backfiring and increasing violence and the militarization of the mining sector while also exacerbating poverty (Greenen 2012, Sematumba 2011).[6] Observers have accused Section 1502 of causing similar problems (Aronson 2011, Sematumba 2011, Seay 2012, Pöyhönen et. al. 2010).[7] Meanwhile, advocacy groups such as the Enough Project have continued to defend the policies as doing more good than damage, especially Section 1502.[8]

The paper proceeds as follows. Section 2 gives background information on artisanal mining in the DRC, on Section 1502 of Dodd-Frank and the mining ban, and on the interactions between militia groups and artisanal miners at mining sites. Section 3 lays out our informal

[6] As Wimmer and Hilgert (2011, 31) put it, the ban did little to prevent violence but it "clearly impacted artisanal miners, most of whom are civilians posing no security threat."

[7] Pöyhönen et. al. (2010, 24), for example, argue that the "U.S. law [Dodd-Frank] risks causing considerable economic damage in Eastern Congo. The end effect can be the opposite of that intended: pushing people towards conflict rather than leading them towards peace" (p. 24).

[8] The head of the Global Witness Congo campaign noted, "It is clear to anyone who observes Congo closely that competition to control and exploit the country's vast mineral wealth is fueling the brutal conflict. The ban on mining activity could provide breathing space for fundamental reforms." He also stated: "The new U.S. law is a very positive step which extends the accountability for abuses in Congo's mining areas up the chain to the companies who are using the products and making millions as a result. We urge other governments to follow suit." See www.globalwitness.org/library/congo-mining-ban-first-step-towards-ending-%E2%80%98conflict-mineral%E2%80%99-trade; last visited on June 6, 2012.

theoretical framework. Section 4 describes the data and section 5 presents our empirical tests. Section 6 concludes.

2. Background

A. Artisanal Mining

The mining sector has been an important contributor to the DRC economy since colonial times. According to the U.S. Geological Survey, the mining sector's recorded contribution to GDP was 13.4 percent in 2009 but the World Bank estimates that it could account for 20-25 percent of GDP if the sector was better managed (World Bank 2008). Mineral deposits are scattered throughout the DRC's eleven provinces, but it is in the eastern part of the country where artisanal mining is infused with armed groups and where the attention on conflict minerals is focused. The eastern provinces usually associated with conflict minerals are mainly North and South Kivu, but also Orientale, Maniema, and Katanga (see Figure 1) (Bawa 2010, D'Souza 2007, De Koning 2011).

Artisanal miners are not officially employed by mining companies but instead work independently using their own resources to pan and dig for alluvial, open pit, and hard rock mineral deposits.[9] Artisanal mining is highly labor intensive and employs minimal technological inputs. Although legal if it occurs in authorized mining areas, most artisanal mining does not (Bawa 2010, De Koning 2011). Estimates of the number of artisanal miners in the five eastern provinces are rough but range from 710,000 to 860,000 with an additional one million artisans

[9] 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." For detailed descriptions and photographs of artisanal mining in the Congo, see De Koning (2010), D'Souza (2007), Bawa (2010), and Pöyhönen et. al (2010).

working in other parts of the country (D'Souza 2007).[10] Some individual mining sites are large. One artisanal mining area, for example, was home to 13,000 people in 2010 (Wimmer and Hilgert 2011). The World Bank (2008, 10) estimates that artisans produce an estimated 90 percent of the minerals exported from the country, "but they do so under very difficult safety, health, and security conditions." D'Souza (2007) estimates that artisanal mining probably constitutes over 80 percent of the entire mining sector production, and he suggests that up to one-fifth of the country's population earns its income through artisanal mining.

The key minerals produced by artisanal miners in the eastern provinces are tin (from cassiterite), tantalum (from coltan and tantalite), tungsten (from wolframite) and gold.[11] The Enough Project provides estimates of the DRC's contribution to world supply of the 3Ts and gold. It estimates the DRC's supply of tantalum at 15-20%; its supply of tin at 6-8%; its supply of tungsten at 2-4%; and its supply of gold at less than one percent.[12]

B. Militarized Mining Sites Prior to the Conflict Mineral Policies

Interactive maps created by the International Peace Information Service (IPIS) suggest that approximately one-half of the artisanal mines in eastern Congo were "militarized" based on visits to mining sites during 2009-2010, before Dodd-Frank was passed.[13] Militarized mines are controlled by, or visited regularly by, armed militias or by the Congolese Army usually for the purpose of taxing extraction. The minerals are transported to buyers located in the border cities

[10] This includes a large number of children working as miners despite being prohibited by Congolese law. According to Bawa (2010), perhaps 40 percent of the miners in eastern provinces are children.

[11] Large volumes of copper and cobalt are also produced by artisans in Katanga. Large volumes of diamonds are produced by artisans in Orientale (World Bank 2008, D'Souza 2007).

[12] http://www.enoughproject.org/files/Comprehensive-Approach.pdf. The Enough Project also estimates that tantalum has provided armed groups in the eastern Congo with $12 million in 2008, tungsten with $7.4 million, tin with $115 million, and gold with $50 million.

[13] See http://www.ipisresearch.be/mapping.php.

of North and South Kivu but also in Orientale and Katanga (United Nations 2011). The minerals are often exported through Rwanda and shipped to Asian smelters before returning to the U.S., Europe, and Asia as components in electronic devices (De Koning 2011).

The most extensive information about militarized mining sites is embedded in two sets of maps: the Militarized Mining Areas of the Kivus, or the "MiMiKi" map, (Spittaels and Hilgert 2009) and the Mining Activity and Mineral Trade in the Kivu Hinterland, or "Hinterlands" maps (Spittaels 2010). The MiMiKi map covers all of the 15 territories in North Kivu and South Kivu. The Hinterlands maps cover 5 of 7 territories in Maniema, 4 of 23 territories in Katanga, and 2 of 25 in Orientale. The 11 territories covered in the Hinterlands map are close to the Kivu borders (see Figure 2).

For each mining site the MiMiKi and Hinterlands maps give the longitude and latitude and the type of mineral deposit (i.e. gold, coltan, cassiterite, and wolframite). For a subset of the mining sites the maps provide estimates of the number of workers and estimate of the price of minerals sold to traders as described below. The maps also indicate which armed group (if any) controls each site along with verbal descriptions of their main activities at the site. Some representative examples are:

- The armed group "controls a part of the site and levy taxes"
- "12 soldiers are present. Anyone entering the site has to pay them FC 500 to 1000"
- "Extortion through false fines and arbitrary arrests"
- "Receive 500 FC from each miner on Thursdays and Fridays; …extort minerals from miners that are returning from the mines; …commit physical harassment."
- "The [armed group] tax the miners, they hire people to work for them and some of them mine themselves."

At other sites, the armed groups are described as “controlling the trade”, “forcing their goods upon miners”, digging themselves, and less commonly, forcing labour to work for them.

To supplement data from the MiMiKi and Hinterlands maps we have also uploaded data from maps of mining sites over the entire Orientale and Katanga Provinces, which are assembled and described by Spittaels and Hilgert (2010) and Spittaels and Hilgert (2008). The Orientale and Katanga maps are not as detailed as the MiMiKi and Hinterlands maps, because they do not give estimates of the number of workers or the details of armed group control. The Orientale and Katanga maps are useful, however, because they supply spatial information on the location of conflict mineral sites across all of the provinces’ territories (see figure 2).

Table 1 summarizes overview information from the MiMiKi, Hinterlands, Orientale, and Katanga maps. Panel A shows the number of mining sites in each province. There are 135,954 known workers at the sites but this is an underestimate because null values were reported when the researchers lacked an estimate and because the Katanga and Orientale maps do not provide any estimates. Of the 640 mining sites, 405 are primarily gold mines and 205 are primarily cassiterite mines. Gold mines are most prevalent in Orientale and North Kivu while cassiterite mines are most prevalent in Maniema and South Kivu. Panel B assigns the known workers to the primary mineral being mined at each site. This leads to an assignment of 58,646 workers to gold mines and 56,568 workers to cassiterite mines. On average, cassiterite mines had 307 known workers per mine and gold mines had 146 known workers per mine.

Table 2 summarizes information from only the MiMiKi and Hinterlands maps regarding the presence of armed groups. Of the 528 site identified by these two maps, 314 apparently lacked a persistent military presence. The mean number of workers per site was lower at these sites, suggesting that armed groups chose to control the more productive mining sites or that

workers may self-select into sites with armed groups present for protection benefits. The FARDC (Armed Forces of the Democratic Republic of Congo) was present at 142 sites, this after its March 2009 merger with the CNDP (National Congress for the Defense of the People). The FDLR (Democratic Forces for the Liberation of Rwanda) was present at 37 sites. Local Mayi-Mayi militia groups were present at 16 sites. It is also worth noting that that the larger armed groups did not specialize in controlling certain minerals but instead spread their presence across mining sites containing different minerals.

C. Dodd-Frank and the DRC Mining Ban

The United States' first legislative attempt to regulate conflict minerals was in April 2009 with the proposed Congo Conflict Minerals Act. That legislation failed to pass but its fundamental goals were carried through as Section 1502 of the Dodd-Frank Act.[14] The central purpose of Section 1502 is to discourage the use of conflict minerals by major manufacturing and processing companies. It also authorized Congress to produce, and make public, a map of mineral-rich zones and illegal armed groups in the eastern region of the DRC. (The map that was produced covers the shaded territories in figure 2).

Section 1502 affects the reporting requirements of perhaps half (at least 6,000) of all publicly traded companies in the United States (KPMG 2011). It directs the Securities Exchange Commission (SEC) to make disclosure rules for companies manufacturing products containing the 3Ts or gold.[15] The rules require companies to conduct "due diligence" on the origin of minerals; if the origin is from the DRC then companies must report on the possibility that

[14] See http://www.opencongress.org/bill/111-s891/show.
[15] The 3Ts and gold are used in a variety of industries including electronics, automobiles, medical equipment, aerospace, and jewelry (KPMG 2011).

warlords have benefitted from the purchases by following the supply chains of minerals (KPMG 2011).[16] The cost to companies of compliance was estimated to be $71.2 million by the SEC but another study puts the cost at $7.93 billion (Bayer 2011).

The Dodd-Frank Act was signed into law on July 20, 2010 (see figure 3). Although the Act did not prohibit the purchase of minerals from the DRC, some observers say it acted as an "intended or unintended boycott of minerals from the DRC" (Pöyhönen et. al. 2010, 27). This is because the easiest way for companies to report being conflict-free is for them to avoid mineral sources from the entire region. The boycotting of eastern DRC minerals has been more explicit since April 1, 2011, when a large coalition of major electronics and high-technology companies completely stopped buying the 3Ts from smelters unable to prove their source minerals did not fund conflict in the Congo (Wimmer and Hilgert 2011).[17]

The DRC governmental ban on artisanal mining and trade in artisanal mined minerals was imposed unexpectedly imposed on September 11, 2010. It covered three provinces - Maniema, North Kivu, and South Kivu (see figure 1). A week after the ban was announced, the Congolese Minister of Mines stated that it only concerned extraction of the 3Ts and not gold (see De Koning 2010) but observers note confusion about whether or not gold was covered. In any case, gold was apparently de facto exempt because it is so easily concealed and smuggled when compared to the 3Ts (De Koning 2011, United Nations 2011). Extraction of the 3Ts was to be halted immediately but traders thought they had until October 15 to sell mineral stocks to

[16] As De Koning (2011, xx) notes: "Under its broad definition of 'armed group', no minerals from eastern DRC can be considered conflict-free where there has been FARDC involvement in the supply chain, and which companies are required to report it."

[17] www.gesi.org/Media/GeSINewsFullStory/tabid/85/smid/503/ArticleID/75/reftab/37/t/GeSI%20and%20EICC%20Announce%20Update%20to%20Conflict-Free%20Smelter%20Program/Default.aspx

exporters and exporters thought they had until November 15 to arrange export (see De Koning 2011).

DRC's President stated the ban's goal was to weed out "mafia groups" from the mining industry, and there were four official reasons given for the ban. These were: "cutting the financing of non-state armed groups, reestablishing state control, fighting against fraud and fighting against the implication of 'non-authorized persons' in the sector" (Geenan 2012, 5). Some observers think the ban was mainly a response to international pressure to stop trade in conflict minerals, and to aid the government in moving from informal artisanal mining to formalized mining (Wimmer and Hilgert 2011, De Koning 2011, Geenan 2012). [18] The ban was lifted without prior warning on March 10, 2011 (De Koning 2011).[19]

How did Dodd-Frank and mining ban impact actual mining? Satellite images and field research indicates that mining of cassiterite, coltan, and wolframite continued, but rates of extraction were significantly reduced (Wimmer and Hilgert 2011, Geenan 2012). Official data on exports reveals a significant drop in exports of tin, coltan, and wolframite during 2010 and 2011. Figure 4a shows the decrease in tin exported from North Kivu and South Kivu, the main tin producing territories of the DRC. As the figure shows, official exports dropped significantly despite the increase in world prices during 2010-2011. Figure 4b shows the official gold exports from Maniema (the only province for which we have found systematic data). Unlike the 3Ts, exports of gold increased during 2010-2011 relative to 2008-2009 exports.

Figure 5 shows monthly export data of tin from North Kivu. We see that official exports went to zero during the ban. Stockpiles were exported in March 2011, during a window of time

[18] Geenan (2012) suggests two additional motives. First, the ban may have been an attempt by the President to replace disloyal army units with more loyal units thereby securing his access to the minerals. Second, the ban may have been used to facilitate control by large industrial mining companies over mining areas.
[19] The ban was lifted with stipulations. See http://www.pole-institute.org/site%20web/echos/echo147.htm.

between the end of the mining ban and April 1, 2011 deadline that western companies had set to stop buying 3T minerals from smelters lacking traceability systems.[20] Chinese companies continued to buy 3T minerals from eastern Congo but apparently at prices discounted of "up to 80 percent compared to world market valuations" (Carisch 2012, 15). By contrast, there is no evidence of major reductions in gold production and export "although [gold] miners came under significant price pressures losing on average 20-25 percent compared to normal selling prices" (Carisch 2012, 15).

3. Theoretical Framework

To guide our empirical analysis we present a highly stylized theoretical framework. Our framework captures the essence of Olson's (2000) stationary bandit idea, and aims to be consistent with the facts about militarized mining sites described above. We fix the amount of warring capital held by heterogenous armed groups and describe the conditions under which it will be 'stationed' at mining sites for the purpose of taxing mineral production. We explain how the policies motivated labor to leave mining sites and migrate elsewhere, losing their 'protected status'. The policies also caused armed groups to spatially re-sort themselves to different mining sites. The joint migration of unprotected laborers, and armed group resorting, triggered violent conflict.

A. Labor Entry and Mining Site Extraction

We imagine *N* artisanal mining sites that contain one of two different minerals, either gold or cassiterite. For simplicity, we assume the price of gold and the 3Ts are initially equal, in

[20] See http://www.pole-institute.org/site%20web/echos/echo147.htm.

period $t = \hat{t}$, but can differ in later time periods. The value of the mining sites can be ranked in ascending order, from *n= 1, 2, 3…N*, based on their mineral endowments $M_{n,\hat{t}}$.

If no armed group controls access to a mining site, homogenous miners will enter it to extract minerals until $p_n q_n(M_n, L_t)/L_n = \bar{w} + x$. The variable p_n is the exogenously given price of a mineral unit and q_n is the quantity of minerals extracted. The variable $\bar{w}$ is the opportunity cost of labor and *x* is the monetized value of 'protection' per time period. Miners at open access mines are 'unprotected' from armed groups. Artisan mining technology is such that the quantity extracted increases with the stock, M_n, and with the number of laborers but at a decreasing rate so that $\partial q_n / \partial M_n > 0$, $\partial q_n / \partial L_n > 0$, $\partial^2 q_n / \partial M_n < 0$ and $\partial^2 q_n / \partial L_n < 0$. The number of laborers at an uncontrolled site is increasing in M_n and p_n and decreasing in $\bar{w}$.

If an armed group does control access to a mining site, then it will impose a per laborer tax, or entry fee, of τ_n. In return, miners receive 'protection', both from the armed group in control and from competing and roaming groups. Miners will enter a militarized mines until $p_n q_n(M_n, L_n)/L_n = \bar{w} + (\tau_n - x)$.

B. Armed Group Control over Mining Sites

There are several armed groups in the Eastern DRC but we assume *J=2* for simplicity.[21] Each group has a fixed amount of physical capital, *K* (e.g., guns), and commands a fixed number of soldiers, *S*. The physical capital is specialized towards war-making and pillaging citizens and is useless for mining. The effective strength of each armed group, denoted by *A*, is such that $A(S,K) = \min[S,K]$. The armed groups can be ranked by effective strength from *j= 1, 2* so that

[21] According to the MiMiKi and Hinterlands maps, *J= 6* different groups but each group work under different commanders that may be somewhat autonomous in practice. The military is one of the armed groups.

$A_1 > A_2$.[22] If the groups battle another for control of a mining site, the probabilities of victory are determined by relative strength so $P(A_1 \text{ defeats } A_2) = A_1/(A_1 + A_2)$, and $P(A_2 \text{ defeats } A_1) = A_2/(A_2 + A_1)$.

The value to an armed group of securing control over a mining site is given by $V^*_{n,\hat{t}} = \rho^t_n \sum_{t=\hat{t}}^{\infty} \tau^*_{t,n} L^*_{t,n}$, which is the optimized present discounted value of taxing labor. The variable $\tau^*_{t,n}$ is the present-value revenue-maximizing tax on each laborer, $L^*_{t,n}$ is the revenue-maximizing number of laborers, and ρ is the discount factor.

The necessary conditions for secure control of a mine are related to the conditions necessary for secure economic ownership of any asset (see Barzel 2002). In our setting, a mine is secured by an armed group if two conditions hold: 1) the armed group has stationed $\hat{a}$ =1 of its capital at the site and 2) it is not rational for the other group to challenge its control.[23] Stationing armed soldiers at sites eliminates unobserved mineral extraction (either from other armed groups or from citizens) and it enables 'protection' of miners. The maximum number of sites either group can control is therefore A_j. We assume that $N - (A_1 + A_2) > 0$ so that some mining sites remain open access.

The second condition is best described by initially assuming an ordering of mine claims in $t = \hat{t}$ based on effective strength. In this ordering, the larger group claims sites $N^{set}_{A1} = 1, 2, ...A_1$ and the second group claims $N^{set}_{A2} = A_1 + 1, ...A_1 + A_2$. Group 2 will not challenge group 1 if the value of group 2's least valuable site exceeds the expected value of group 1's most valuable site.

[22] For our short-run analysis, we rule-out the possibility of mergers and divisions of armed groups and we assume each group can observe the effective strength of other groups.

[23] These same ownership requirements were important in the evolution of property rights to mines in Australia, the United States, and elsewhere (see e.g., Anderson and Hill 1975, La Croix 1992, Umbeck 1977, and Libecap 2007).

That is, group 1 will not challenge if $V^*_{A1+A2,\hat{t}} \geq P(A_2 \text{ defeats } A_1)V^*_{1,\hat{t}}$. This no-challenge condition can be rewritten as $V^*_{A1+A2,\hat{t}} / V^*_{1,\hat{t}} \geq P(A_2 \text{ defeats } A_1)$.[24] Figure 6 illustrates.

C. A Stationary Bandit Equilibrium

A stationary bandit equilibrium is one in which all capital is a 'stationed' at mining sites and a stream of steady production emanates. It exists in period $t = \hat{t}$ under two conditions.

1. No armed group could gain expected tax revenue by relocating some of its capital to a different site, either to challenge another group or to take-over an open access site
2. No laborer could gain by leaving mining sites and migrate elsewhere (which would entail losing protection status).

D. Mining Policies and Roving Bandits

We hypothesize that Dodd Frank and the mining ban broke down the stationary bandit equilibrium in period $t = \hat{t} + 1$. First, the policies authorized government officials to impose strict penalties on any miner caught mining (see Geenan 2012). This raised the tax parameter τ_n, at least in expectation, at all mining sites. Moreover, the policies sharply lowered the local price for gold and the tin (see section 2). These effects would cause labor to exit mining areas, thereby losing their protection status as valued workers.

Second, the mineral policies increased the value of gold mining sites relative to 3Ts sites for two reasons. First, the policies caused the local price of tin (and presumably tungsten and tantalum) to fall more dramatically than the local price of gold (see section 2). Second, the

[24] For example, if the most valuable mine has a present discounted value of \$100,000 and the least valuable has a present discounted value of \$40,000, then group 2 will not contest unless $P(A_2 \text{ defeats } A_1) > 0.4$.

policies made the future of artisanal 3Ts mining much more uncertain. This implies that $\rho^G > \rho^{3T}$ after the policies; when we have no reason to believe that $\rho^G \neq \rho^{3T}$ prior to the policies. The significant changes in relative prices and discount rates caused a new ranking of mineral sites, with gold mines rising up the rankings and tin mines sliding down. With the rankings re-ordered, large armed group would rationally abandon the lowest valued 3T mines (potentially looting miners and civilians on the way out) so to acquire gold mines that have become relatively more valuable. The re-ordered rankings also caused smaller armed group to abandon its lower valued 3T mines (potentially looting miner and civilians on the way out) in order to take over formerly open access gold mines (potentially intimidating workers on the way in).

Figure 7 summarizes our theory. We hypothesize the increase in exiting laborers, lacking 'protection', combined with the abandonment of 3T mines and the takeover of gold mines by armed groups, all increased the probability of violence against citizens and the probability of conflict between armed groups.

E. Anecdotal Evidence

We can point to anecdotal evidence that is consistent with our theoretical framework. There is qualitative information about what happened at Bisie, the largest artisanal mine in North Kivu. Prior to the mining ban, Bise was home to about 13,000 people including 3,000 miners who were able to keep about 50 percent of the cassiterite mined. Within two days after the imposition of the ban, 1200 miners left for the nearby town of Ndjingala. Most other miners left Bisie by October 2010. According to Wimmer and Hilgert (2011, 8) armed groups routinely

extorted from and physically harassed former miners en route from Bise and surrounding mines to the trading town of Ndjingala.

Geenan (2012, 6) researched South Kivu mining villages before and during the mining ban. She concludes the ban led to greater incidences of thefts, robberies, armed attacks, and murders. Other assessments provide lucid examples of the FARDC taking control of small gold mining sites in the Kivus and Maniema that were formerly unoccupied by armed groups, or that were formerly occupied by smaller militias (see United Nations 2011, Carisch 2012). In one case a man lost his arm in a confrontation with a soldier who had recently arrived to guard the entrance of a formerly non-militarized mine. [25] We did not find descriptions of FARDC takeover of small 3T mining sites in the literature we reviewed.

4. Data and Graphical Analysis

To formally test some of the implications of the theory, we employ data on armed civil conflict, the location of artisanal mining sites (described in section 2), and on world mineral prices.

A. Conflict Data

The civil conflict data come from the Armed Conflict Location and Event Dataset (ACLED).[26] This dataset reports information on internal political conflict disaggregated by date, location, and by actor or actors for several unstable and African countries, including the DRC.

The ACLED currently covers 1997-2011 for the DRC. The unit of analysis is a "politically violent event" occurring on a specific date (day) and at a specific location (longitude

[25] Also see http://texasinafrica.blogspot.com/2010/12/drc-mining-ban-view-from-kamituga.html

[26] The ACLED data are available at www.acleddata.com and are described in Raleigh et. al (2010).

and latitude). Battles or conflicts lasting multiple days are recorded as separate "atomic" incidents, and this fact is important to keep in mind when interpreting the data. The ACLED events are coded as either battles, violence against civilians, riots, or non violent events. Conflict actors in the DRC include Unidentified Armed Groups, the FDLR, the Mayi Mayi Militia, the CNDP, the Union for Democracy and Social Progress, Military Forces of the DRC, and Civilians. The dataset includes verbal descriptions of conflicts. Some examples are: "Ongoing offensive against FDLR/Mayi Mayi sees government regain cobalt mines"; "Ambush by FDLR leaves 5 soldiers and 2 police killed, 2 injured, and 3 rebels killed"; "A group of renegade soldiers are suspected of raping 150 women and girls in a location known as Nyakiele over the course of three days"; and "Two armed bandits are killed by police and another two arrested when they attacked a mining company depot."

Figures 8a and 8b summarize the ACLED data for the DRC. Figure 8a shows the number of conflicts by day from 1997 – 2011. There were 4,388 conflict events spread across 42 percent of the days during this period, with some noteworthy periods of reprieve. Figure 8b shows the annual number conflicts broken down into two categories: violence against citizens and all conflicts. The highest total number of conflicts was 559 in 2008. The lowest number of conflicts was in 2011, at 80, providing some indication that the conflict mineral regulations and bans may have reduced the incidence of conflict. Closer inspection of the data with regression analysis indicates the converse is true, at least in the near aftermath of the policy changes. Figure 8b also shows that violence against citizens has comprised a higher proportion of conflicts since 2009. From 1997-2008, the percent of conflicts against citizens averaged 20.7 compared to an average of 54.7 from 2009-2011.

B. Mineral Prices

The mineral price data come from MetalPrices.com, which requires a subscription for historical data. From the website we have downloaded data on the world prices of gold, tin, tantalum, and tungsten for the longest time periods for which data are available. The gold prices are reported in dollars per troy ounce. The prices of the 3Ts are reported in dollars per pound.

Figure 9 shows the monthly averages for 1997 – 2011, the period for which the ACLED conflict data are available. The monthly averages are CPI adjusted and reported in U.S. dollars. Of the four minerals, gold has experienced the most consistent increase in price, reaching $1641 per ounce by the end of 2011.[27] The price of tin has vacillated since 1997, reaching a high of $14.77 per pound in April 2011. The price of tungsten (from wolframite) spiked dramatically in 2005 and stayed high until 2008. It rebounded with a world price of $22.75 per pound in December 2011. The price of tantalum (from coltan) with African origin spiked dramatically in 2000-2001. It has risen since the beginning of 2010, and was $129 per pound in December 2011.

C. Graphical Evidence

Figures 10a and 10b provide initial evidence that the mining ban increased conflict. Figure 10a compares the number of conflicts per day in provinces with the ban (Maniema, North Kivu, and South Kivu) against the conflict rate in the remaining provinces. It shows that conflict was occurring at a lower rate in Maniema and the Kivus during the three-month window before Dodd Frank was passed (April 20, 2010 to July 20, 2011). By contrast, conflict occurred at a

[27] According to the IPIS interactive maps, traders in the Hinterlands reported selling gold in the range of $508 to $1039 per ounce from various villages and cities during 2009-2010. Traders in the Hinterlands reported selling cassiterite in the range of $4.89 to $13.44 per pound from various villages in cities during 2009-2010. Traders in the Hinterlands reported selling tantalum for prices ranging from $19.55 to $66.00 per pound from various villages and cities during 2009-2010. There is only one report of wolframite prices from traders in the Hinterlands during 2009-2010; the sale price was $4.89 per pound.

higher rate in the areas subjected to the mining ban during the period after Dodd-Frank was enacted and before the mining ban was lifted. Figure 10b shows a similar result, but for the subset of conflicts involving violence against citizens. In both figures, we see the rate of conflict increased in provinces subjected to the ban but it decreased in provinces not subjected to the ban.

Figures 11a and 11b show evidence that conflicts spiked upward in the banned provinces immediately after the imposition of the mining ban. The data shown in the figures are broken down into 40 time periods to allow for a three-month window around the policy changes. This is achieved by dividing the days from April 20, 2010 until June 10, 2011 into 10-day intervals. For example, April 20-30 2010 is time period 1, May 1-10 2010 is time period 2, May 11-20 2010 is time period 3, May 21-31 is time period 4 and so on. Hence, Dodd-Frank was passed at the beginning of time period 10, the July 21-31 interval. The ban was imposed in time period 15, the September 11-20 interval. It was lifted in time period 31, the March 11-20, 2011 interval. Figures 11a and 11b show sharp increases in Maniema and Kivu conflict and violence against citizens when the ban was first imposed, and marked decreases when the ban was lifted.

Figures11a and 11b also show an upward spike in conflict and violence against citizens when the Dodd-Frank legislation was enacted in the provinces subjected to the ban. The provinces subjected to the ban, however, are not exactly the same areas that would have been subjected to a de facto embargo caused by the Dodd-Frank Act. Which Eastern DRC areas were directly impacted by Dodd-Frank due diligence requirements? Our best guess is that it would be those mining areas that the U.S. State Department identified as being exploited by armed groups. The exploited areas are identified in a U.S. Dept. of State map, which is unclassified and was made publicly available on June 14, 2011.[28] The State Dept. map combines data from the IPIS

[28] See https://hiu.state.gov/Products/DRC_MineralExploitation_2011June14_HIU_U357.pdf, visited on June 27, 2012.

maps of North and South Kivu, and the Hinterlands of Katanga, Maniema, and Orientale, which we describe in section 2. For the empirical analysis that follows, we consider the 26 territories covered in the MiMiKi and Hinterlands maps to be subject to Section 1502 requirements. These are the shaded territories in figure 4.

5. Regression Analysis

Although we estimate the effects of both Dodd-Frank and the mining ban, the setup is more conducive for identifying the effects of the mining ban. This is true because the mining ban was abruptly imposed in three of eleven provinces on September 10, 2010 and abruptly removed on March 10, 2011. The two regime shifts moved in opposite directions, which helps to isolate the effects of the mining ban "treatment" from general time trends (see Meyer 1995). By contrast, the Dodd-Frank regulation did not cleanly respect provincial or territory boundaries, it was phased in slowly, and it has not been repealed. For these reasons, we devote more attention to the mining ban.

A. Baseline Regression Analysis

The raw ACLED data are available in highly disaggregated forms, so we must choose if and how to aggregate the data spatially and temporally prior. Spatially our choices range from the highest administrative unit – the 11 provinces – to the lowest which is a village. We present our analysis at the territory level, which is a middle-ground compromise between highly disaggregated and highly aggregated approaches. We avoid greater spatial disaggregation in part because the spatial location of mines and conflicts is not always known with precision. We drop from our analysis all territories in the six provinces for which we lack data on the location of

artisanal mines prior to Dodd Frank. We therefore focus our analysis on the *N =70* territories in the Eastern DRC (see figure 2). We have run our tests at the provincial level, however, and find qualitatively similar results when we include all eleven provinces.[29]

Temporally we focus our analysis at the daily level although we have also analyzed data aggregated up to monthly and seasonal observations and find little qualitative differences in our empirical results.[30] We choose to create daily observations rather than monthly observations for three reasons. First, the mining policy changes varied at the sub-monthly level so using daily observations allows us to account for the precise timing of the policies. Second, some of the control variables we hope to eventually include – including rainfall, weather, and world mineral prices – can in principal be obtained at the daily level. Third, using daily observations eliminates some of the over-dispersion problems in the data (see below) and makes it less necessary to employ estimators of count data (e.g., poisson, negative binomial) that rely on strong parametric assumptions.

We present here our analysis of daily conflicts within the 70 territories in the five eastern provinces of Katanga, Maniema, North Kivu, Orientale and South Kivu. Table 5 presents summary statistics of the dependent variables. In each territory, there are 5,478 observations, which is the number of days from 1997 to 2011, yielding a total of 383,460 observations. The mean number of conflicts per day is 0.0095 with a maximum of 8. We include all of the days back to 1997 because this enables us to also estimate the long-run relationship between world

[29] Regression results from different levels of spatial aggregation are available upon request. Other studies have found that spatial aggregation has a large impact on empirical relationships between world mineral prices and violent conflict (see De Luca et al. 2012). By contrast, the impacts of the conflict mineral policies do not appear sensitive to spatial aggregation choices, at least not the choices we have tried.

[30] Regression results from different levels of temporal aggregation are available upon request.

mineral prices and conflicts and to control for the effects of world prices in our analysis of the conflict mineral policies (see table 5).

We have run poisson and negative binomial regressions and find similar results but here we present OLS regressions of the form:

$$Conflicts_{id} = \beta(mining\ ban)_{id} + \mu(doddfrank)_{id} + \delta_t + \alpha_i + \theta_m + \pi_p Year + \varepsilon_{id}$$

where *i*=the 70 territories, *d*= the 5478 days, *t*=the 180 one-month time periods from 1997 to 2011, *m*= the 12 months within each year, and *p*= the 5 provinces. We initially do not control for world mineral prices for reasons explained below.

The notation δ_t represents the 180 time period effects, α_i represents the 70 territory fixed effects, and θ_m represents the fixed effects for each of the 12 months. The territory fixed effects help control for factors that are relatively time invariant, and known to be important determinants of conflict, such as ethnic composition and fractionalization (see Esteban et al 2012). The monthly indicators control for conflict cycles that may relate to seasonal climate and agricultural production.[31] The time period effects control for country-wide factors that may cause changes in conflict, such as presidential elections or changes in national inflation.

In lieu of including territory specific parametric time trends, the notation $\pi_p \cdot Year$ indicates that we allow each province to have a year specific intercept. We employ this strategy because any parametric trends of daily conflict would be extremely complex (see figure 8a). Our province specific year intercepts control for annual changes in the conflict environment of each province that may be correlated with the conflict mineral policies.

[31] In future drafts we hope to add to the model data on weather conditions across the different territories because previous research has found a correlation between these climate events and civil conflict in a panel of countries (see Hsiang et al 2011, De Luca et al. 2012).

Table 4 gives regression results of variants of equation (2), with robust t-statistics given in parentheses.[32] Columns 1-2 are the baseline specifications. Each of the baseline specifications estimate a strong, positive relationship between the mining ban and conflict. To appreciate the magnitude of the coefficients, consider that the 2010 mean for daily conflicts prior to Dodd Frank and the mining ban in Maniema, North Kivu, and South Kivu was 0.0115. Hence, the column 1 coefficient of 0.066 represents a 57 percent increase in conflict during 2010. Column 2 provides evidence that the Dodd-Frank Act also increased conflict.

Columns 3-6 use different strategies to control for the possibility that the columns 1-2 coefficients are inflated upwards because of conflicts that may have begun prior to the policies and then spilled over into the policy periods. Controlling for temporal spillover is particularly important in the context of ACLED data because extended conflicts are counted as separate incidents for each day they persist (see section 3). In columns 3 and 4, we include pre-policy indicators for the 30 day time period preceding the mining ban and Dodd Frank. The coefficients on the pre-ban indicators are negative and statistically insignificant for the mining ban territories, indicating there was not a run-up in conflicts preceding the mining ban. Although the coefficient on the pre-Dodd Frank indicator is statistically insignificant, it is positive with a reasonably high t-statistic of 1.44, which suggests that some of the violence during the Dodd Frank period may be carryover from preceding conflicts.

The specifications in columns 5 and 6 use a different tact to account for differences in pre-policy conflicts across the territories. In these columns we drop territories from the sample that had any conflicts within 10 days prior to the mining ban or within 10 days prior to the Dodd Frank Act. We choose 10 days because regression results indicate that the 10-day window is sufficient to capture the impact of lagged conflicts on contemporary conflict (see column 1, table

[32] We have also clustered the standard errors by N=70 territory and this yields similar inferences.

A1 in the appendix). [33] Dropping the 10-day window observations has a small effect on the estimated coefficients, indicating the results may be partly driven by pre-policy conflict. Finally, we are confident that the policy-variable coefficients are also not biased by the spatial spillover from conflicts in adjacent territories because our regression results indicate that lagged daily conflicts in adjacent territories have little impact on daily conflict within a territory (see column 1, table A1).

Columns 7-10 present the most compelling results by allowing the effects of the policies to vary across territories based on the intensity of mining activity prior to the policies. In columns 7 and 8, we interact the mining ban and Dodd Frank with the number of gold and 3T mines in each territory (see table 1 and figure 2). In both cases, the interaction effects are positive, implying that the policies had the most pronounced adverse effects in areas where mining was a large source of livelihoods. Indeed, in territories lacking conflict mines, there is not a significant relationship between the policies and conflict.

In columns 9 and 10 we allow the policy effect to differ across gold mines and the 3T mines. We choose to combine the 3T mines into one category because often deposits coltan, cassiterite, and wolframite are found at the same mining site. The results are similar to those found in column 7 and 8, in that they indicate that the adverse effects of the policies on conflict are concentrated in mining areas. Column 10 shows that the Dodd Frank variable has its largest effect in the territories concentrated with 3T mines. This may be because the Dodd Frank

[33] One strategy might be to control directly for lagged daily conflicts as we do in table 4, with the temporally aggregated data. Controlling directly for lagged conflict is not appropriate here, however, because it would lead us to underestimate the policy effects. The reason why is because each day of the conflict is treated as a separate conflict in the ACLED data, and many conflicts last multiple days. Adding 10 days of lagged effects to the regression model in equation (2) would ascribe less weight to the consecutive days of an extended that began during the policy periods.

regulated companies have recently stopped buying 3T minerals from smelters without traceability systems (see figure 3), but have had a less formal program in place to boycott gold.

Table 5 shows the same specifications as shown in table 4, but the dependent variable is the number of episodes of violence against citizens. The results are generally consistent with those shown in table 4 but there are some noteworthy differences. In table 4, we found no evidence of higher levels of conflict in territories subjected to the ban that lacked mining sites. By contrast, table 5 shows some evidence of an increase in violence against citizens in mining ban territories lacking mines (see columns 8 and 10). This may be because citizens migrated to non-mining areas and were victimized by armed groups en route.

B. The Effect of Mineral Prices

The regression tables in table 4 and table 5 do not control for world mineral prices, which seems a glaring omission in a study of conflict and natural resources. Indeed, commodity prices are the key focus of many papers that study whether or not increases in resource values leads to more conflict (see, e.g., Collier and Hoeffler 2004, Angrist and Kugler 2008, Brückner and Ciccone 2010, Dube and Vargas 2012, De Luca et al. 2012).

But there are problems with including world mineral prices in our regressions. First, as discussed in section 2, the local price received by miners and traders in the wake of Dodd Frank and the mining ban may bear little resemblance to the world price. As figure 12 shows, the world prices of tin and gold were rising when the prices received locally were falling. Second, Dodd Frank and the ban may have caused increases in the world prices of some conflict minerals. Figure 12 provides visual evidence that is consistent with this view as are a host of media

articles.[34] Sample headlines include "Tin Prices Jump as Congo Embargo Foreseen" and "Tantalum Prices Boosted by DRC Conflict Zone Mining Ban".

With this caveat in mind, we present regressions in table 6 that control for the monthly world prices of the 3Ts and gold. In column 1, we add interaction terms between the monthly world prices of gold and tin with an indicator variable for territories in North Kivu, South Kivu, and Maniema. The indicator variable is obviously time invariant over 1997-2011. In column 2 we add interaction terms for the world prices of tungsten and tantalum; data on these prices were not available for all months since 1997 (see figure 9). In columns 3 and 4, we interact the world prices with the number of artisanal mining sites of each type in each territory during 2009-2010, before Dodd Frank was passed. Our variable of the number of artisanal mining sites is time invariant over 1997-2011.

The regression results in table 6 show that relationships between world mineral prices and conflict are sometimes negative and sometimes positive, depending on the mineral and the specification. In all cases, however, controlling for world prices does little to diminish the economic and statistical significance of the mining ban and dodd frank coefficients. We conclude that the omission of world prices in table 4 and 5 is not significantly biasing our coefficient estimates on either policy variables.

[34] Media articles suggesting a relationship between the conflict mineral policies and the prices of tantalum can be found at www.mineweb.com/mineweb/view/mineweb/en/page72102?oid=115025&sn=De and www.resourceinvestor.com/2012/02/10/dodd-frank-australian-cuts-threaten-tantalum. Media articles on the relationship between conflict mineral polices and tin prices can be found at http://www.resourceinvestor.com/2010/11/09/tin-prices-jump-as-congo-embargo-foreseen and http://tininvestingnews.com/852-tin-prices-at-historic-highs-on-supply-deficit.html. Media articles on the relationship between conflict mineral policies and tungsten supply can be found at http://www.ctia.com.cn/TungstenNews/2011/78166.html. Also see http://www.pole-institute.org/site%20web/echos/echo147.htm.

C. Using Historical Mineral Prices to Test the Theory

Our theoretical framework suggests that one the mechanisms from the conflict mineral policies to more conflict was through the sharp change in the relative values of gold and 3T mines. We plan to further examine the plausibility of this channel by analyzing the historical effects of sharp changes in the relative prices of minerals on conflict in mining areas. [These tests are coming soon].

6. Conclusions

The top-down decisions to ban artisanal mining in the DRC and to regulate companies using those minerals did not result in a reduction in conflict during the time period we study. The long term effects remain to be seen, but the short term effects have been fatal for some Congolese citizens. Instead of reducing violence, our evidence indicates the policies have increased the number of armed conflicts in the eastern DRC.

Our results contribute to a large literature on the interaction between resource prices, resource endowments, and violence. We join others in concluding that the resource curse, if real, is a complex phenomenon that is unlikely solved by simple actions to reduce the value of a country's natural resource endowment. This finding is related to the literature on the perverse effects of boycotts on products that are produced using unethical methods.[35]

We have focused on the short-run impacts empirically and theoretically but an examination of the longer run impacts would be fruitful. Such an examination would require us to relax our theoretical assumption that armed capital is fixed, and instead allow weaponry and

[35] Basu and Zarghamee (2009), for example, find that consumer boycotts of products produced with child labor can cause child labor to rise, rather than fall, when alternative employment opportunities are not provided. Our findings are related because we find evidence that Congolese citizens were harmed by mining embargoes that were not complemented with alternative employment opportunities.

soldiers to fluctuate in response. As others have suggested, reductions in the value of a fragile country's natural resources may motivate people to join militia groups (see Janus 2011, Dube and Vargas 2012) thereby escalating the probability of violence. Although reducing the profit of illicit armed groups and individuals who partake in the mineral trade seems to be a good thing, it is possible that fewer guns may actually increase violence (see Ralston 2012).

Considering the persistent and lagged effects of conflict, however, the long-run effects of the conflict minerals are perhaps permanently affected by what happens first, in the short run. In this sense, a full understanding of the long-run relationship between conflict and natural resources may require first understanding what happens in the immediate aftermath of large shifts in resource values and related policies. The analysis here takes a step in that direction by showing how a set of policy shocks triggered violence that likely changed the path towards peace.

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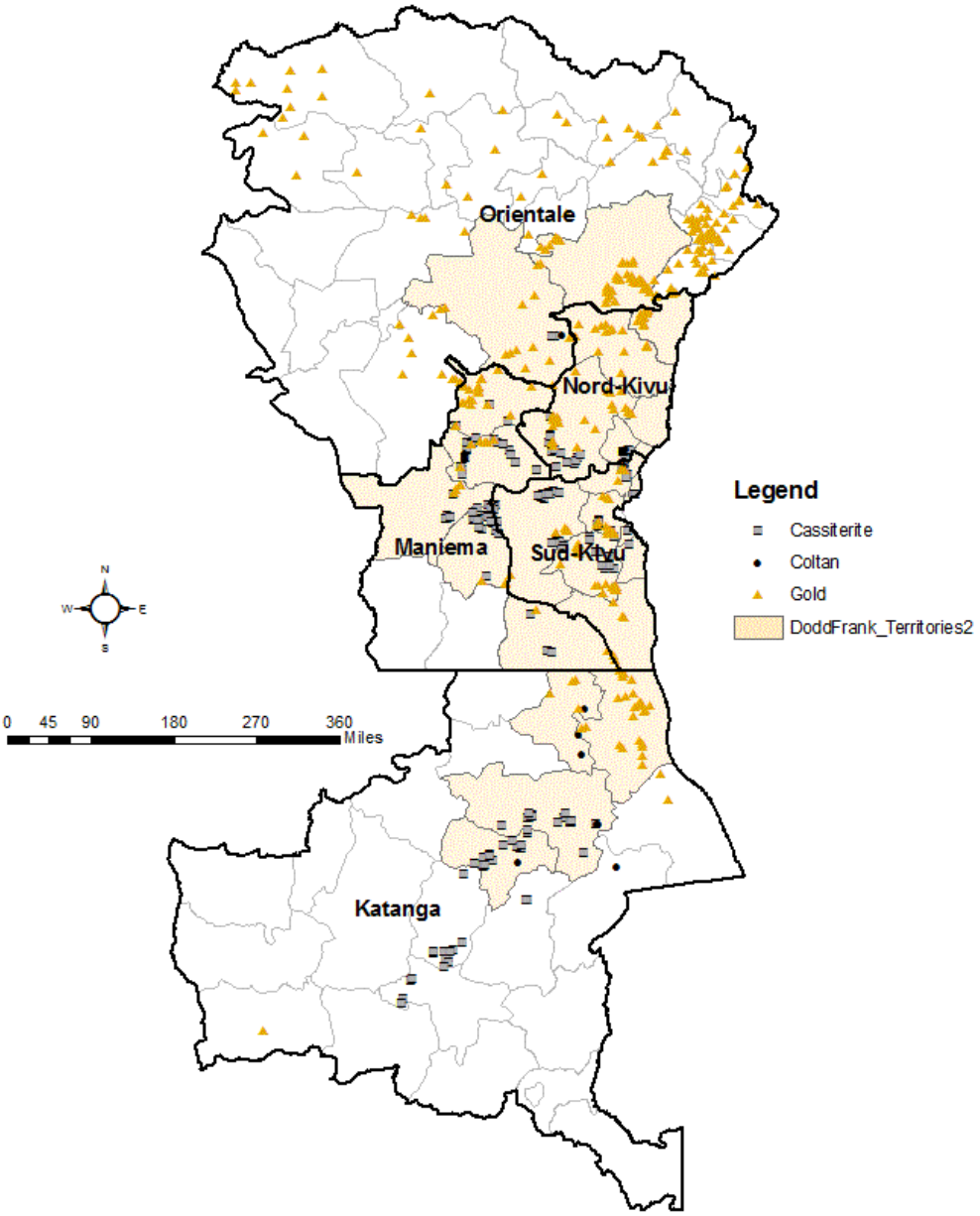
Figure 1: Provinces of the Democratic Republic of Congo

Figure 2: Artisanal Mining Sites in the Eastern DRC



Notes: The shaded territories are those with the militarized mining areas as described in the MiMiKi and Hinterlands' maps created during 2008-2010.

Figure 3: Timeline of Key Mineral Regulations

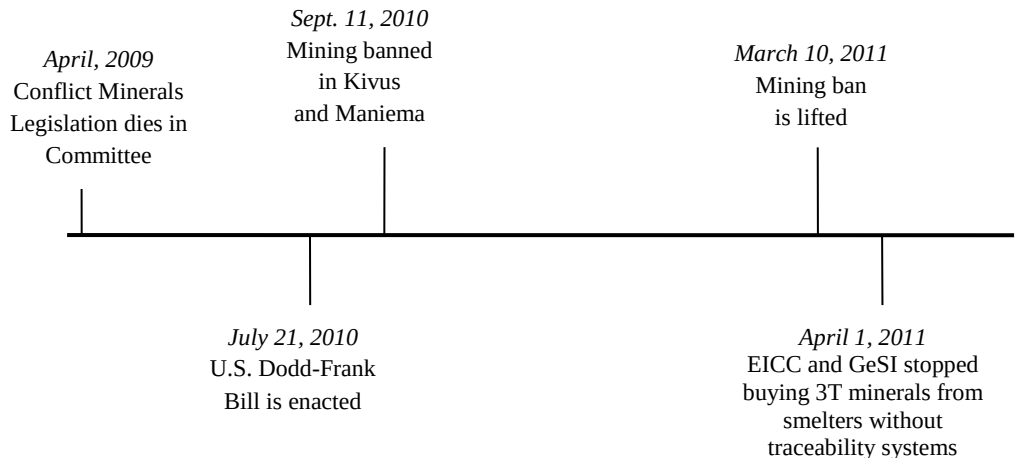
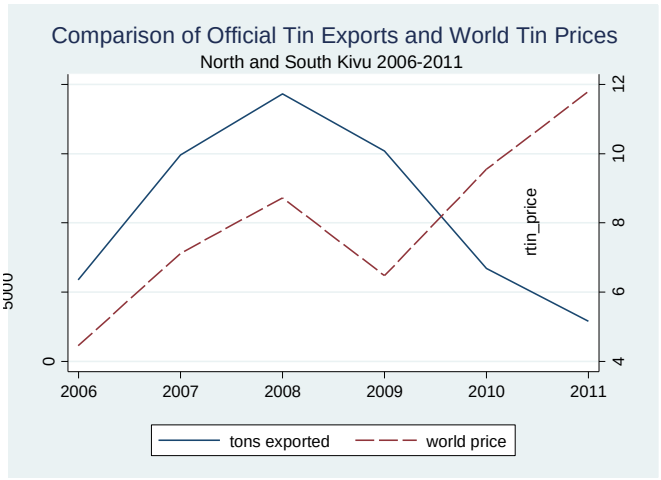
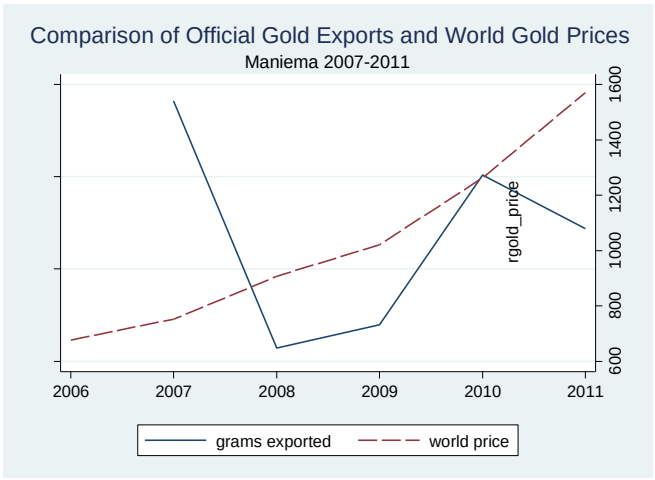


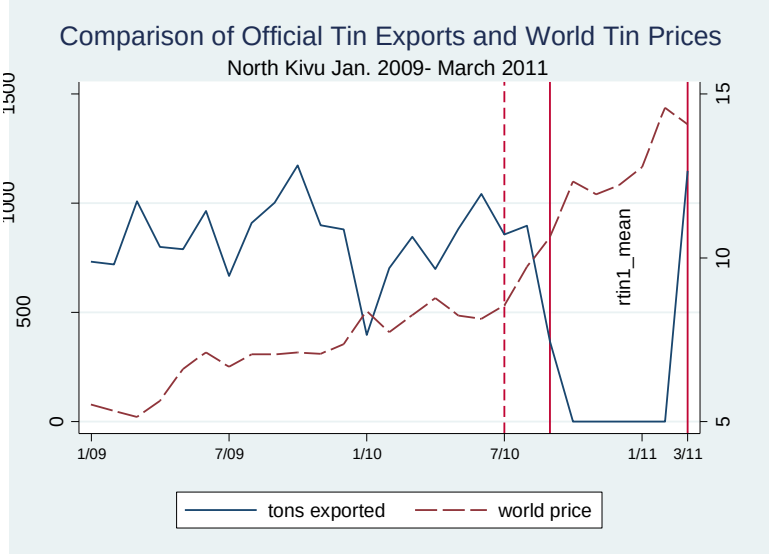
Figure 4a and 4b: Annual Official Exports of Tin and Gold





Source: De Koning (2011), USGS Minerals Yearbook (http://minerals.usgs.gov/minerals/pubs/country/2010/myb3-2010-cg.pdf) , USGS annual reports on tin production (see http://minerals.usgs.gov/minerals/pubs/commodity/tin/mcs-2013-tin.pdf and http://minerals.usgs.gov/minerals/pubs/commodity/tin/mcs-2012-tin.pdf and Carish (2012).

Figure 5: Monthly Official Exports of Tin from North Kivu



Notes: The solid vertical lines contain the months for which the mining ban was in effect. The dashed vertical line is for July 2010, the month that Dodd-Frank was signed into law.

Figure 6: Initial Ordering of Mine Control

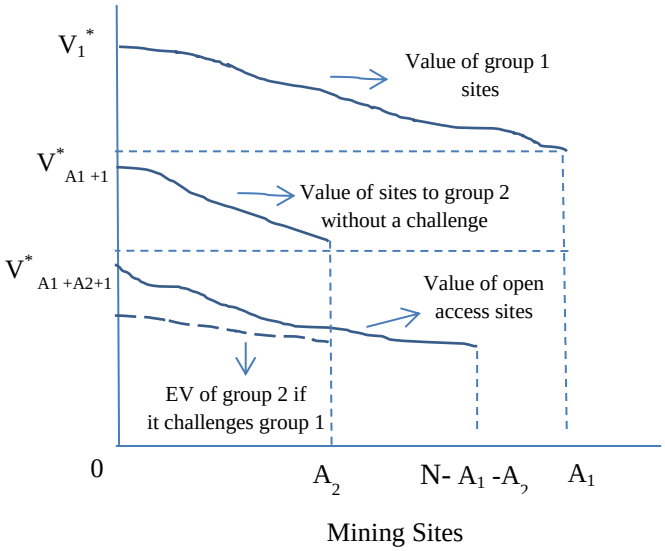


Figure 7: Summary of Theory

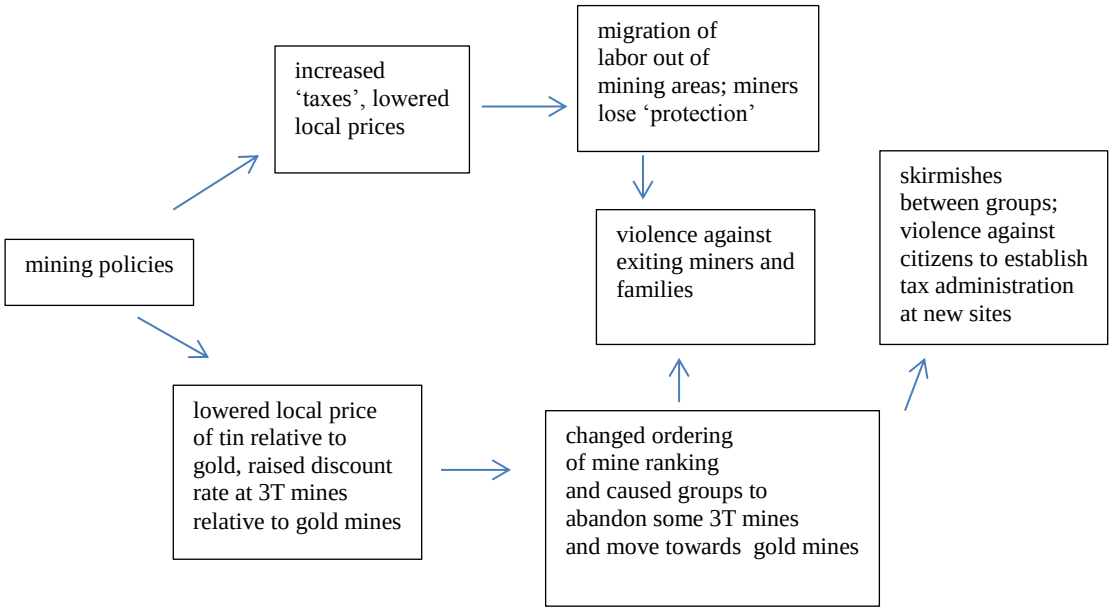
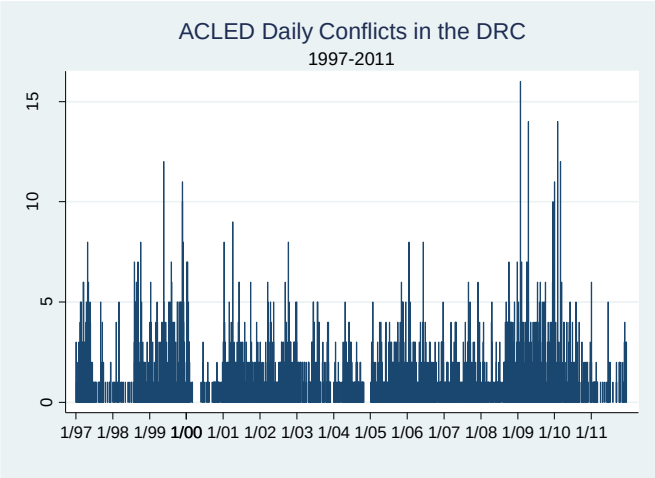


Figure 8a and 8b: ACLED Conflicts in the DRC, 1997-2011



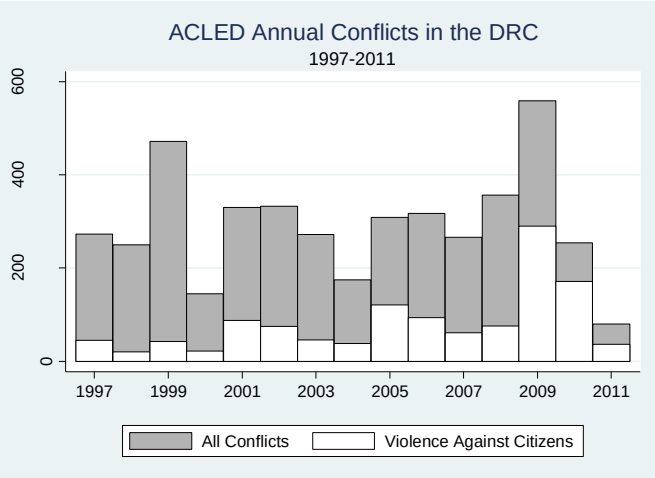


Figure 9: World Prices of Conflict Minerals, 1997-2011

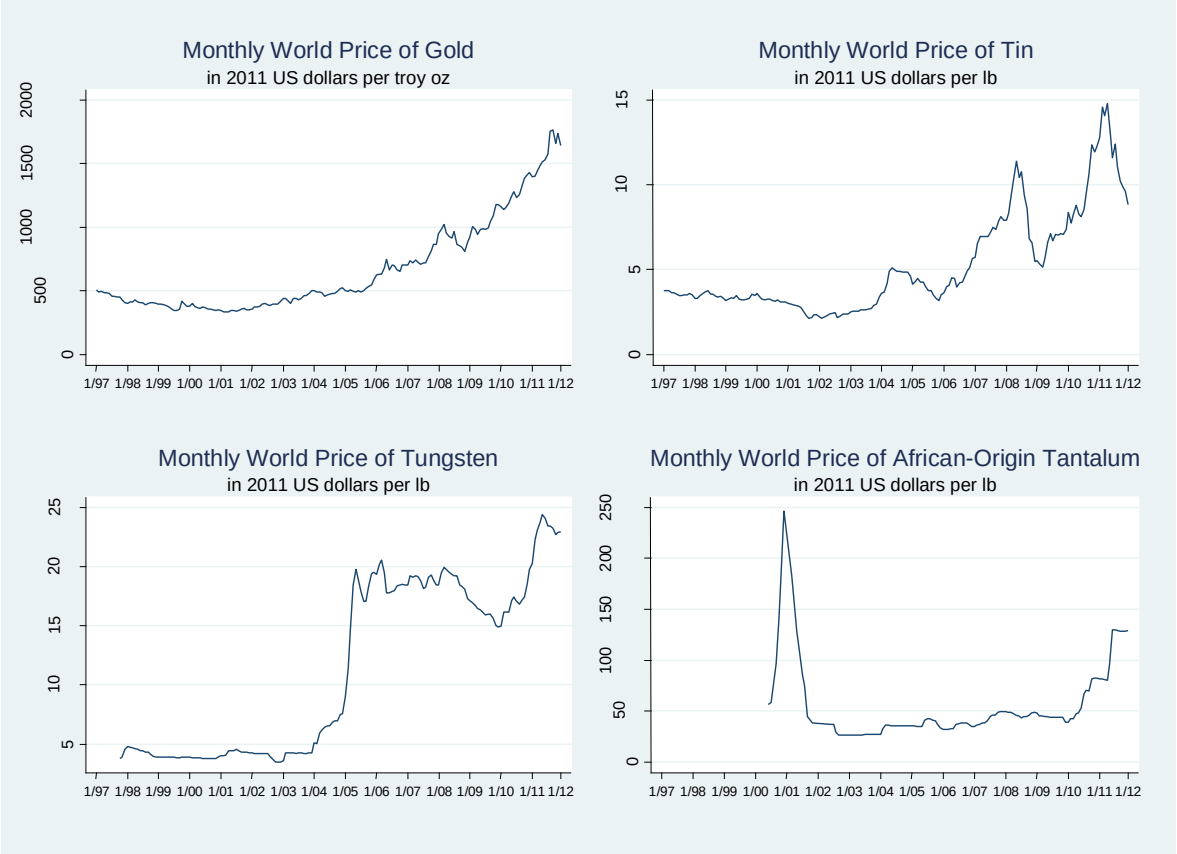
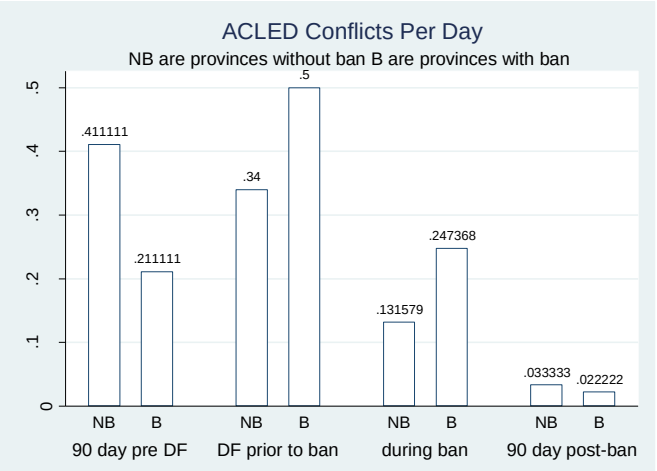


Figure 10a and 10b: Conflicts per day in 90 Day Window around Policy Changes



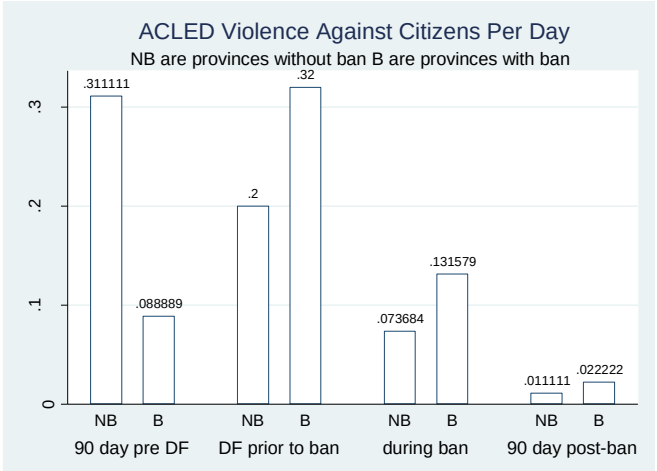


Figure 11a and 11b: Flow of Conflicts in 90 Day Window around Policies

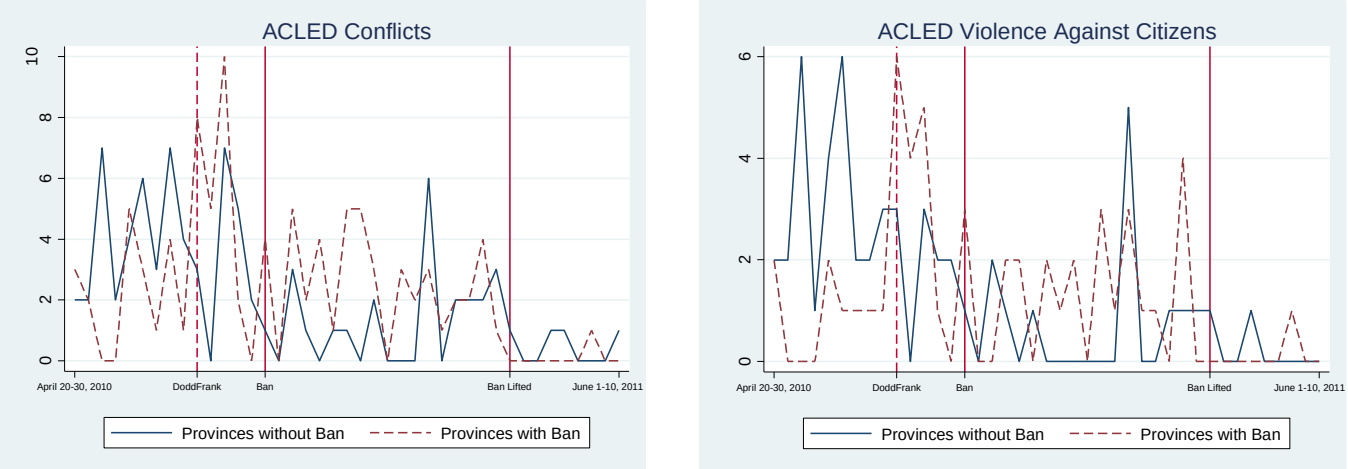
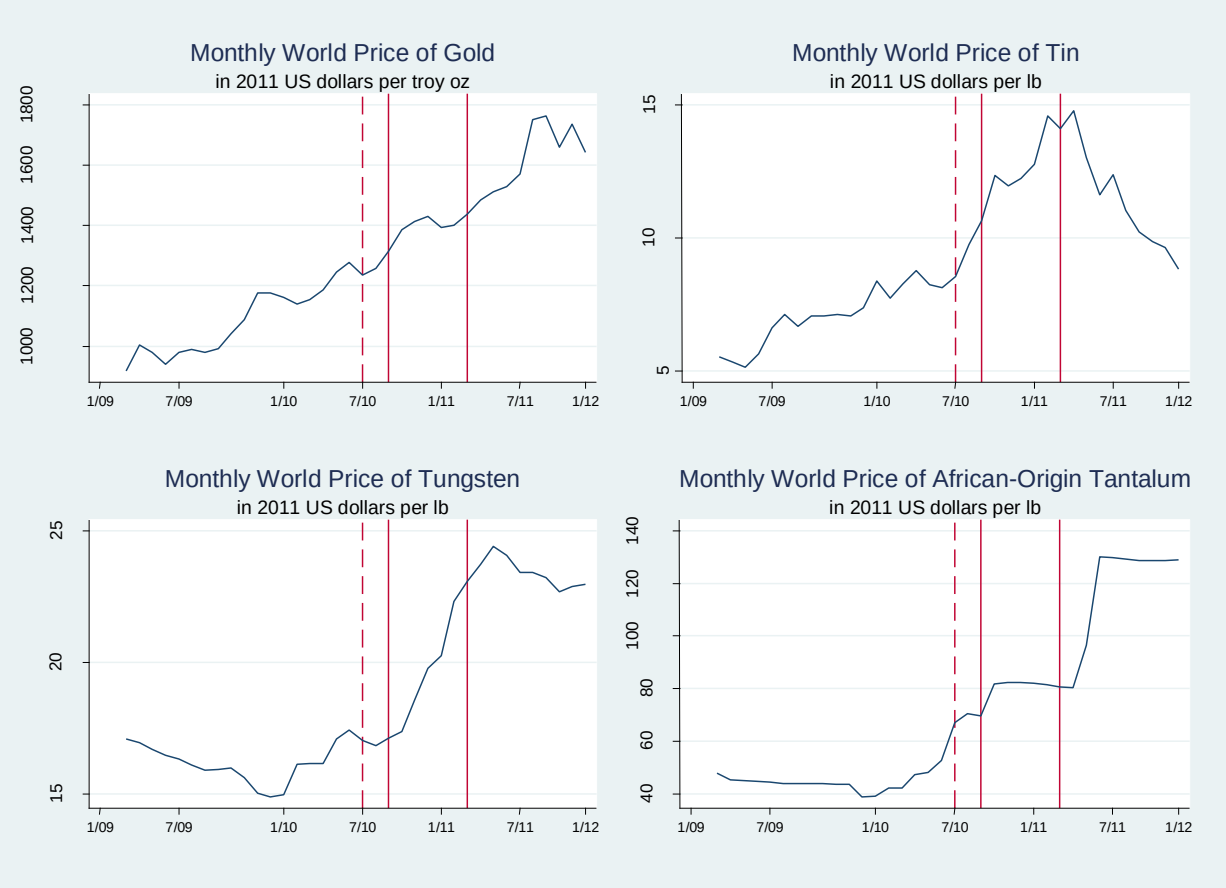


Figure 12: World Prices of Conflict Minerals from 2009-2011



Notes: The solid lines contain the months for which the mining ban was in effect. These months are September 2010 through March 2011. The dashed line is for July 2010, the month that Dodd-Frank was signed into law.

Table 1: 3T and Gold Mining Sites in Eastern DRC Prior to Conflict Mineral Policies
(by primary mineral)

Panel A: Mining Sites and Mining Deposits

	Known Workers	Mines	Gold	Cassiterite	Coltan	Wolframite
Source: MiMiKi Map						
N. Kivu	9,860	96	67	19	9	1
S. Kivu	26,700	119	58	53	2	6
Source: Hinterlands Map						
Katanga	15,923	56	20	31	5	0
Maniema	66,845	144	59	79	4	1
Orientale	10,642	85	82	2	1	0
Source: Orientale Map						
Orientale non-Hinterlands	NA	116	116	0	0	0
Source: Katanga Update Map						
Katanga non-hinterlands	NA	24	3	21	1	0
Total	*129,970*	*640*	*405*	*205*	*22*	*8*

Panel B: Known Workers by Primary Mineral

	Known Workers	Mines	Gold	Cassiterite	Coltan	Wolframite
N. Kivu	9,860	96	3,550	4,710	1,544	55
S. Kivu	26,700	119	12,457	9,148	370	4,077
Katanga	15,923	56	5,238	6,485	4,200	0
Maniema	66,845	144	29,839	35,145	140	50
Orientale	10,642	85	7,562	1,080	2,000	0
Orientale non-Hinterlands	NA	177	NA	NA	NA	NA
Katanga non-Hinterlands	NA	24	NA	NA	NA	NA
Total	*129,970*	*640*	*58,646*	*56,568*	*8,254*	*4,182*

Notes: The estimates of the "known workers" are underestimates of artisans working in these provinces. In many cases, there is no estimate given for workers at a mining site. The data are listed by primary mineral but, in some cases, more than one mineral is mined from a site. The hinterlands map inventoried mines from a subset of territories in Katanga, Maniema, and Orientale. For Katanga, the territories covered are Kalemie, Malemba-Nkulu, Manono, and Nyunzu. For Maniema, the territories covered are Kabambare, Kailo, Lubutu, Pangi and Punia. For Orientale, the territories covered are Bafwasende and Mambasa. The Orientale map covers all of the province but with less detail than the Orientale Hinterlands map. For example, the Orientale map does not estimate the number of workers in the mines. The maps are described in detail at Spittaels and Hilgert (2009), Spittaels 2010, and Spittaels and Hilgert (2010).

Table 2: Militarized Mining Sites in Eastern DRC Prior to Conflict Mineral Policies
(by primary mineral)

Armed Group Present	Mines	Gold	Cassiterite	Coltan	Wolframite	Known workers
None Identified	314	150	144	10	7	60,252
FARDC	142	100	31	9	1	42,493
FDLR	37	24	12	1	0	4,801
Mayi-Mayi Militias	16	8	6	1	0	6,125
PNC	11	0	11	0	0	15,899
FRF	7	7	0	0	0	---
Other	1	0	1	0	0	400
Total	*528*	*289*	*204*	*21*	*8*	*129,570*

Notes: The estimates of "known workers" are underestimates of artisans working in these provinces. In many cases, there is no estimate given for workers at a mining site. The data come from the MiMiKi and Kivu Hinterlands maps described in Spittaels and Hilgert (2009) and (see Spittaels 2010). The MiMiKi maps are based on data collected during May-July 2009. The Hingerlands maps are based on data collected during June-July 2010. The FARDC is the Armed Forces of the Democratic Republic of Congo, which merged with the CNDP (National Congress for the Defense of the People) in March 2009. The FDLR is the Democratic Forces for the Liberation of Rwanda. Mayi Mayi is an umbrella term for loosely affiliated groups of local militias. The PNC is the National Congolese Police. The FRF is the Forces Républicaines Fédéralistes.

Table 3: Summary Statistics of Daily Conflict by Eastern Province

	Y = All Conflicts			*Y = Violence Against Citizens*			
	Mean	*Max*	*Variance*	*Mean*	*Max*	*Variance*	*N*
Katanga Province							
Bukama	0.003286	2	0.003641	0.00073	2	0.001095	5478
Dilolo	0.003651	1	0.003638	0	0	0	5478
Kabalo	0.002191	2	0.002551	0.000183	1	0.000183	5478
Kabongo	0.004564	2	0.004909	0.001095	1	0.001094	5478
Kalemie	0.004929	2	0.005636	0.001826	1	0.001823	5478
Kambove	0.001278	1	0.001276	0.000183	1	0.000183	5478
Kamina	0.001643	1	0.001641	0	0	0	5478
Kaniama	0.000183	1	0.000183	0	0	0	5478
Kapanga	0.000183	1	0.000183	0.000183	1	0.000183	5478
Kasenga	0.000548	1	0.000547	0.000183	1	0.000183	5478
Kipushi	0.00073	2	0.001095	0.000183	1	0.000183	5478
Kongolo	0.000548	1	0.000547	0.000183	1	0.000183	5478
Lubudi	0.000548	1	0.000547	0.000183	1	0.000183	5478
Lubumbashi	0.006572	3	0.009086	0.001826	2	0.002188	5478
Malemba-Nkulu	0.001278	1	0.001276	0.000365	1	0.000365	5478
Manono	0.004929	2	0.005636	0.00146	1	0.001459	5478
Mitwaba	0.001278	1	0.001276	0.00073	1	0.00073	5478
Moba	0.007119	2	0.008896	0.000365	1	0.000365	5478
Mutshatasha	0	0	0	0	0	0	5478
Nyunzu	0.003103	1	0.003094	0.000365	1	0.000365	5478
Pweto	0.011318	2	0.011922	0.00146	2	0.001824	5478
Sakania	0.004381	2	0.005093	0.000365	1	0.000365	5478
Sandoa	0	0	0	0	0	0	5478
Maniema Province							
Kabambare	0.009127	2	0.009411	0.001278	1	0.001276	5478
Kasongo	0.002373	3	0.003829	0.000548	1	0.000547	5478
Kibombo	0.000183	1	0.000183	0	0	0	5478
Kindu	0.012413	2	0.014818	0.002008	2	0.00237	5478
Lubutu	0.001643	1	0.001641	0.000365	1	0.000365	5478
Pangi	0.002008	2	0.00237	0.000365	1	0.000365	5478
Punia	0.003103	1	0.003094	0.00073	1	0.00073	5478
North Kivu Province							
Beni	0.020993	3	0.024938	0.005842	1	0.005809	5478
Goma	0.023914	4	0.028093	0.006207	3	0.007265	5478
Lubero	0.025009	4	0.032787	0.008397	2	0.009789	5478
Masisi	0.034684	5	0.051015	0.008762	2	0.009783	5478
Rutshuru	0.060606	6	0.103684	0.014056	3	0.018243	5478
Walikale	0.044907	5	0.072476	0.014786	3	0.018222	5478

Table 3: Summary Statistics of Daily Conflict by Eastern Province
(Continued)

	Y = All Conflicts			*Y = Violence Against Citizens*			
	Mean	*Max*	*Variance*	*Mean*	*Max*	*Variance*	*N*
Orientale Province							
Aketi	0.001278	1	0.001276	0.000183	1	0.000183	5478
Ango	0.009127	4	0.016349	0.008945	4	0.01617	5478
Aru	0.004929	1	0.004905	0.003103	1	0.003094	5478
Bafwasende	0.006572	2	0.007625	0.000365	1	0.000365	5478
Bambesa	0.000365	1	0.000365	0.000365	1	0.000365	5478
Banalia	0.000183	1	0.000183	0	0	0	5478
Basoko	0.000183	1	0.000183	0	0	0	5478
Bondo	0.000183	1	0.000183	0	0	0	5478
Buta	0.00073	1	0.00073	0	0	0	5478
Djugu	0.023184	5	0.03324	0.003468	2	0.003822	5478
Dungu	0.041073	8	0.090516	0.02793	8	0.068783	5478
Faradje	0.007485	3	0.010351	0.004016	2	0.005096	5478
Irumu	0.070464	4	0.102392	0.014421	2	0.017137	5478
Isangi	0.002738	1	0.002731	0.000548	1	0.000547	5478
Kisangani	0.000365	1	0.000365	0.000365	1	0.000365	5478
Mahagi	0.006754	1	0.00671	0.001826	1	0.001823	5478
Mambasa	0.002738	2	0.003096	0.000548	1	0.000547	5478
Niangara	0.006389	4	0.010001	0.005842	4	0.009095	5478
Opala	0.000365	1	0.000365	0	0	0	5478
Polo	0.006024	2	0.006719	0.002373	1	0.002368	5478
Rungu	0.006389	2	0.00781	0.00146	2	0.001824	5478
Ubundu	0.002921	1	0.002913	0.000365	1	0.000365	5478
Wamba	0.000365	1	0.000365	0.000183	1	0.000183	5478
Watsa	0.002191	2	0.002551	0.001643	1	0.001641	5478
Yohuma	0.000548	1	0.000547	0	0	0	5478
South Kivu Province							
Bukavu	0.032494	3	0.040207	0.011318	2	0.011557	5478
Fizi	0.017707	2	0.021049	0.002738	1	0.002731	5478
Idjwi	0	0	0	0	0	0	5478
Kabare	0.014969	3	0.018399	0.008032	2	0.00943	5478
Kalehe	0.018803	4	0.023565	0.006937	2	0.007255	5478
Mwenga	0.020993	3	0.026764	0.005659	2	0.005993	5478
Shabunda	0.016977	3	0.018153	0.004564	3	0.005639	5478
Uvira	0.030486	4	0.04855	0.008945	2	0.009962	5478
Walungu	0.003103	2	0.00419	0.000548	1	0.000547	5478
Total	**0.00949**	**8**	**0.013546**	**0.002884**	**8**	**0.003945**	**383,460**

Table 4: OLS Regressions of Daily Conflicts in territories of Five Eastern Provinces

	Baselines		Controlling for Pre-Policy Conflicts				Allowing Effects to Vary with No. of Mines			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 month prior to ban			-0.0032	-.00422						
			(0.49)	(0.64)						
Mining Ban	.006638**	.005783**	0.0063***	.00558**	0.00414*	.005224**	0.0005	0.00226	0.00068	.002771
	(2.86)	(2.46)	(2.60)	(2.28)	(1.96)	(2.50)	(0.23)	(0.98)	(0.28)	(1.21)
1 month prior to Dodd-Frank				.00859						
				(1.44)						
Dodd Frank		0.00256*		.00326***		.001095		-0.00199		-.002276
		(1.93)		(2.56)		(1.06)		(1.11)		(1.27)
Mining Ban x No. of Mines							0.00043***	0.0030**		
							(3.49)	(2.41)		
Dodd Frank x No. of Mines								0.00016***		
								(3.00)		
Mining Ban x No. of Gold Mines									0.00059**	.000491**
									(2.85)	(2.35)
Mining Ban x No. of 3TsMines									0.00027*	0.00002
									(2.23)	(0.16)
Dodd Frank x No. of Gold Mines										0.00013**
										(2.43)
Dodd Frank x No. of 3T Mines										0.00029***
										(3.19)
70 territory fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
180 time effects+	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
12 seasonal -month effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
5 Province-specific year effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	383,460	383,460	383,460	383,460	367,026	356,070	383,460	383,460	383,460	383,460
Adjusted R^2	0.0236	0.0236	0.0236	0.0237	0.0234	0.0218	0.0237	0.0237	0.0237	0.0237

Notes: *** statistically significant at p<0.01,** p<0.05, * p<0.10. Robust t-statistics are in parenthesis. +Time effects are for each month since 1997. In columns (5) and (6) the omitted territories with a conflict within 10 days prior to the ban are Dungu, Masisi, and Shabunda. The omitted territories with conflict within 10 days of the passage of Dodd Frank are Beni, Dungu, and Irumu.

Table 5: OLS Regressions of Daily Episodes of Violence Against Citizens in territories of Five Eastern Provinces

	Baselines		Controlling for Pre-Policy Conflicts				Allowing Effects to Vary with No. of Mines			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 month prior to ban			0.0031	.002359						
			(0.68)	(0.52)						
Mining Ban	.004771***	.004011**	0.00506***	.004498**	0.00229	.002238	0.0028	0.0037**	0.0289	0.004**
	(2.78)	(2.37)	(2.84)	(2.52)	(1.43)	(1.39)	(1.60)	(2.27)	(1.66)	(2.57)
1 month prior to Dodd-Frank				.000088						
				(0.15)						
Dodd Frank		0.00228**		.002420***		.002210***		-0.0003		-0.0005
		(2.44)		(2.80)		(2.78)		(0.26)		(0.49)
Mining Ban x No. of Mines							0.00013	0.00004		
							(1.92)*	(0.57)		
Dodd Frank x No. of Mines								0.0001***		
								(2.79)		
Mining Ban x No. of Gold Mines									0.00016	0.001
									(1.34)	(0.83)
Mining Ban x No. of 3TsMines									0.0001	-0.0009
									(1.21)	(0.97)
Dodd Frank x No. of Gold Mines										0.00006*
										(1.94)
Dodd Frank x No. of 3T Mines										0.00023***
										(3.75)
70 territory fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
180 time effects+	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
12 seasonal -month effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
5 Province-specific year effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	383,460	383,460	383,460	383,460	377,982	372,504	383,460	383,460	383,460	383,460
Adjusted R^2	0.0112	0.0112	0.0112	0.0112	0.0099	0.0099	0.0112	0.0112	0.0112	0.0112

Notes: *** statistically significant at p<0.01,** p<0.05, * p<0.10. Robust t-statistics are in parenthesis. +Time effects are for each month since 1997. In columns (5) and (6) the omitted territory with a conflict within 7 days prior to the ban is Dungu. The omitted territories with conflict within 7 days of the passage of Dodd Frank are Beni and Dungu.

Table 6: OLS Regressions of Daily Conflicts in territories of Five Eastern Provinces with Controls for World Mineral Prices

	(1)	(2)	(3)	(4)
Mining Ban	0.00613**	0.00697**	0.0051**	0.0051**
	(2.14)	(2.11)	(2.13)	(2.11)
Dodd Frank	0.0036***	0.0040***	0.0038**	0.0029*
	(2.79)	(2.97)	(2.36)	(1.76)
Gold Price x Mining Ban Territory	-0.00009	-0.00012	-5.75e-07***	
	(3.10)***	(3.79)***	(3.69)	
Tin Price x Mining Ban Territory	-3.85e-06	-0.00001	6.94e-07***	
	(0.21)	(0.60)	(2.87)	
Tant. Price. x Mining Ban Territory		0.00006		
		(1.23)		
Tung. Price. x Mining Ban Territory		0.00005***		
		(2.75)		
Gold Price x No. of Gold Mines				-4.47e-07**
				(2.56)
Tin Price x No. of Tin Mines				1.30e-06***
				(5.03)
Tant. Price x No. of Coltan Mines				2.24e-06
				(0.19)
Tung. Price x No. of Wolframite Mines				2.97e-06**
				(2.32)
70 territory fixed effects	YES	YES	YES	YES
180 time effects+	YES	YES	YES	YES
12 seasonal -month effects	YES	YES	YES	YES
5 Province-specific year effects	YES	YES	YES	YES
Observations	383,460	272,860	383,460	272,860
Adjusted R^2	0.0237	0.0288	0.0237	0.0287

Notes: *** statistically significant at p<0.01,** p<0.05, * p<0.10. Robust t-statistics are in parenthesis. +Time effects are for each month since 1997. In columns (5) and (6) the omitted territories with a conflict within 10 days prior to the ban are Dungu, Masisi, and Shabunda. The omitted territories with conflict within 10 days of the passage of Dodd Frank are Beni, Dungu, and Irumu.

Table A1: Temporal and Spatial Lags in Daily Conflicts at Territory Level

	Y= Conflicts	Y=Violence against Citizens
1 day lag of dependent variable in territory	.2330892**	.1513334**
	(.0118077)	(.0166808)
2 day lag of dependent variable in territory	.1187764**	.0916591**
	(.0093699)	(.0127764)
3 day lag of dependent variable in territory	.0426335**	.0285034**
	(.0081966)	(.0098487)
4 day lag of dependent variable in territory	.033058**	.0509776**
	(.007752)	(.0133456)
5 day lag of dependent variable in territory	.0313509**	.0169891*
	(.007377)	(.0086817)
6 day lag of dependent variable in territory	.0257377**	.0006638
	(.0067942)	(.0069611)
7 day lag of dependent variable in territory	.0272846**	.038377**
	(.0073491)	(.0105988)
8 day lag of dependent variable in territory	.0025493	-.0018743
	(.006426)	(.0063884)
9 day lag of dependent variable in territory	.0130269*	.013884
	(.0072051)	(.0099712)
10 day lag of dependent variable in territory	.017695*	.0014902
	(.0080599)	(.0072475)
11 day lag of dependent variable in territory	.0179842	.024271
	(.0122085)	(.0169584)
12 day lag of dependent variable in territory	.0035284	-.0082446
	(.0069055)	(.0067391)
13 day lag of dependent variable in territory	.0029859	.0055846
	(.0054735)	(.0065274)
14 day lag of dependent variable in territory	.013823*	.0144099
	(.0057271)	(.0081316)
15 day lag of dependent variable in territory	.0085969	.0148322
	(.0062522)	(.0129952)
1 day lag of dep. var. in adjacent territories	-.0001259	-.000364
	(.0012477)	(.0015309)
2 day lag of dep. var. in adjacent territories	.0005171	-.0012629
	(.0012396)	(.0012577)
3 day lag of dep. var. in adjacent territories	.0022339*	.0004293
	(.0012318)	(.0017242)
4 day lag of dep. var. in adjacent territories	.0008094	.0013729)
	(.0011747)	(.0015451)
5 day lag of dep. var. in adjacent territories	-.0014307	-.0004512
	(.0011215)	(.0014175)
70 territory fixed effects	YES	YES
180 time effects***	YES	YES
12 seasonal -month effects	YES	YES
5 Province-specific year effects	YES	YES
Observations	382,410	382,410
Adjusted R^2	0.1446	0.0635

Notes: ** statistically significant at $p<0.05$, * $p<0.10$. t-statistics are in parenthesis. The standard errors are not clustered. The appropriate model is a negative binomial or zero inflated negative binomial model rather than the OLS model presented here. ***Time effects are for each month since 1997.