Resource Cursed or Policy Cursed?

The Violent Consequences of Conflict Mineral Legislation in the DRC*

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Abstract: There is widespread perception that international consumption of "conflict minerals" is a leading cause of brutal violence and armed conflict 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 mining in three of its provinces during 2010-2011. We develop a theory to explain why the policies could backfire, causing violence to increase rather than fall. Our reasoning is inspired by Mancur Olson's (2000) *stationary bandit* metaphor, research on conflict and natural resources, and a literature on the citizen 'protection' functions served (and coerced) by organized criminals. We test for the short-term policy effects by merging geo-referenced datasets on armed conflict, militarized mining sites, and mineral prices from 2008-2011. The evidence suggests the policies increased the incidence of violent conflict shortly after their enactment. The increased violence was targeted at civilians (rather than militias), but militia battles shifted from regulated tin, tungsten, and tantalum mining territories towards unregulated gold territories.

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1. Introduction

The belief that some poorly governed countries are cursed by their natural resources is pervasive and it sometimes influences international policies towards trade in resources with those countries. When a country is afflicted by the rawest form of the resource curse, increased international demand for its resource endowments leads to violent civil conflict rather than improved human welfare. In theory, increased demand can be both the incentive for armed conflict, because there are larger spoils to fighting, and the fuel to sustain conflict because revenues from sales finance weaponry and soldiers (see, e.g., Hirshleifer 1991, Grossman 1991, Collier and Hoeffler 2004, Janus 2011, Olsson 2007).

In this paper, we study a region that is, at least ostensibly, the quintessential example of a place afflicted by the resource curse: the eastern Democratic Republic of the Congo (DRC). The DRC is the world's 11th largest country by area and the 19th most populated. It ranks 215th out of 216 countries in national assessments of human rights protections, 156th out of 162 countries in assessments of peacefulness, and dead last in GDP per capita.[1] The eastern DRC contains minerals that supply surging world markets for mobile phones, tablets, flat screen televisions, and other modern electronic devices. The region is rich in natural resources, but poor by every conceivable measure of human welfare.

There is a poignant fact that contributes to the widespread perception that the eastern DRC is cursed by surging global demand for its minerals. It is clear that some revenue from their sale goes to warlords and armed thugs who control aspects of the trade and sometimes commit brutal acts of violence. This is why human rights advocacy groups have dubbed the endowments "conflict minerals", which officially refers to tin, tungsten, tantalum, and gold from the region.

Convinced that the DRC suffers from the resource curse, advocacy groups such as the Enough Project and Global Witness, have successfully lobbied for top-down policies to reduce international demand for Congolese minerals extracted with armed group involvement. The primary policy is the U.S. Dodd-Frank Act of 2010, Section 1502, which was endorsed by co-sponsor Barney Frank as a measure to "cut off funding to people who kill people" (Aronson 2011). Section 1502 regulates large western companies whose products may contain conflict minerals. It has acted as an "intended or unintended boycott" on purchases of tin, tantalum, and

[1] See www.ihrri.com/contry.php, www.visionofhumanity.org/#/page/indexes/global-peace-index, and data from the World Bank at http://data.worldbank.org/indicator/NY.GDP.PCAP.CD.

tungsten – the "3Ts" - from the eastern DRC (Pöyhönen et. al 2010, 27). Gold, however, has been de facto exempt because it is more easily concealed and smuggled. Two years after Dodd-Frank was passed, advocacy groups were claiming success, stating "the passage of conflict minerals legislation … have helped lead to a 65% drop in armed groups' profits from trade in tin, tantalum, and tungsten …" (Johnson 2013, p. 53).

But did the legislation actually reduce violent civil conflict? The evidence we present here suggests that it did the opposite, actually causing the incidence to rise rather than fall. In this paper, we empirically and theoretically examine effects of Section 1502 on the incidence of violent armed conflicts in the eastern DRC. We theoretically describe mechanisms through which the policies could backfire, in the short-run, causing violence near mining sites to increase rather than fall. We test the theory by employing geo-referenced and detailed data on militarized mining sites and on armed conflict shortly before and shortly after the policies, from 2008 through the end of 2011. The evidence suggests the legislation increased the incidences of violence against civilians in and near mining territories, and the incident of militia battles near gold mining sites, during the time interval we study.

In studying what went wrong, we employ an analytical approach that complements but differs from other studies of how shocks to the value of resource endowments affect violence in poorly governed countries with weak property rights. That literature is predominantly concerned with two competing effects: the rapacity effect and the opportunity cost effect. On one hand, a rise in endowment values means there are larger spoils to fighting, so the rapacity (or predation) effect implies an increase in violence in response (see Hirshleifer 1991, Grossman 1991, Olsson 2007).[2] On the other hand, positive shocks to resource values increase the opportunity cost of fighting, drawing labor away from militias and into non-conflict, non-criminal industries (see Becker 1968, Grossman 1999).

Focusing on these theoretical effects suggests the key to understanding whether violence rises or falls with resource-value shocks lies in understanding the extent to which resource commodity production is labor rather than capital intensive (Dube and Vargas 2013). In cases where production is labor intensive (e.g., agriculture), the opportunity cost can dominate but in

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[2] Recent empirical support for the dominance of the rapacity effect is provided by Angrist and Kugler (2008) who find a positive relationship between coca prices and violence in Columbian municipalities dependent on coca production. 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.

cases where production is capital intensive (e.g., oil extraction), the rapacity effect can dominate.[3] Importantly, mining in the eastern DRC is highly labor intensive, with almost no capital inputs (see section 2). This fact suggests the opportunity cost effect may dominate in our empirical setting. If it does, violence should have increased as a result of Section 1502, which dramatically lowered the net value of mineral endowments to local civilians and militias. Thus, opportunity cost is one candidate explanation for our empirical findings.

The opportunity cost concept, however, does not obviously explain patterns of conflict that we observe. First, the policies primarily increased violence against civilians, rather than increasing militia battles, and it is not clear to us why falling opportunity costs of militia participation would have this asymmetric effect. Second, to the extent the policies increased battles between militias, it did so only in gold mining territories rather than elsewhere in the eastern DRC. This nuance is not explained by blanket decreases in the opportunity cost of militia participation; it is actually better explained by rapacity to fight over unregulated gold.

Rather than relying on rapacity and opportunity cost tradeoffs for theoretical guidance, we develop a simple theory that is inspired by research on the economic functions of organized crime (see Skaperdas 1992, Skeperdas 2001), and by Mancur Olson's (2000) *stationary bandit* metaphor.[4] Stationary bandits are akin to Mafia groups that tax production in neighborhoods (or illicit industries) they control. They emerge in power vacuums, where the state is absent, to provide protection (Skaperdas 2001). Mafia groups maximize revenues by selling protection to civilians – both against crime they will commit themselves (if not paid coerced taxes) and against crime committed by others. Hence, if one Mafia group has the power to monopolize taxing authority, there will be little to no ordinary violence, except for the occasional brutal act committed against civilians as a credible display of force (Konrad and Skaperdas 1997). Yet this low-violence, stationary bandit equilibrium is precarious. Mafia groups must find it

[3] Dube and Vargas (2013) 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. Similarly, 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.

[4] Our theoretical reasoning is related to that of Maystadt et. al (2014), who model the incentives of armed groups to exploit and protect mineral resources in the DRC using ideas from the crime displacement literature, and to de la Sierra (2014), who also analogizes armed groups in the DRC to stationary and roving bandits.

advantageous to protect rather than harm civilians, and to remain in a neighborhood or industry rather than moving to challenge the areas controlled by competing groups.

Applying this analogy to the eastern DRC, mafia groups are armed militias, artisanal mining villages are neighborhoods, and the relevant industries are 3T and gold mining. As we describe in section 2, the mafia characterization fits our setting, where there is clearly a power vacuum created by the lack of state authority. We refer to detailed surveys of militarized mining sites, which describe how the sites were controlled by "mafia-like" groups who "taxed" labor in somewhat predictable ways, prior to Dodd-Frank. In exchange, the armed groups provided a crude form of protection.

For these reasons, our theory in section 3 assumes that militia groups choose between stationing their armed capital at mining sites for the purpose of taxing, roving and looting civilians, or challenging another militia group for mining assets. Section 1502 and related policies sharply lowered the present value to militias of stationing their soldiers at 3T sites, but had less of an effect on the present value of taxing labor at gold mining sites. We explain how this asymmetric shock could have triggered a sequence of violence, first against civilians near 3T deposits as militias ceased 'protection', leaving a power vacuum. Logically, the next wave of violence would be in gold mining territories as armed groups competed for control over gold deposits. These are detailed predictions that we examine empirically, after first testing for the more general reduced form effects of the policies.

The paper proceeds as follows. Section 2 gives background information on artisanal mining in the eastern DRC, on Section 1502 of Dodd-Frank and a related mining ban, and on the taxing practices of militia groups at mining sites prior to Dodd Frank. Section 3 lays out our theoretical framework. Section 4 describes data and section 5 presents empirical tests and discusses how the results relate to other economic studies of violence and mining in the DRC (Maystadt et al. 2014, de la Sierra 2014), and to observers in the DRC, who have accused the policies of exacerbating poverty, unemployment, and violence in mining regions that had provided income for an estimated 710,00 to 860,000 miners (see Aronson 2011, Sematumba 2011, Pöyhönen et. al. 2010, Sematumba 2011, Greenen 2012, Seay 2012).[5] Section 6 concludes with a brief discussion of possible policy implications.

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[5] 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." Pöyhönen et. al. (2010, 24) argue that the "U.S. law

2. Background

A. Artisanal Mining Prior to Dodd Frank

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 if the sector was better managed (World Bank 2008). Mineral deposits are scattered throughout the eleven provinces, but it is in the east 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 and Maniema, but sometimes also Orientale 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.[6] Artisanal mining is labor intensive and employs minimal technological inputs.[7] 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 artisans produce 90 percent of the minerals exported from the country, "under very difficult safety, health, and security conditions."

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. The Enough Project estimates the DRC's contribution to world supply of the 3Ts and gold. For tantalum, the estimate is 15-20%; for tin 6-8%; for tungsten 2-4%; and for gold, less than one percent. However, tin and gold have generated much more local revenue in absolute terms.[8]

[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).

[6] 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 descriptions of artisanal mining in the DRC, see De Koning (2010), D'Souza (2007), Bawa (2010), and Pöyhönen et. al (2010).

[7] The lack of capital investment is almost certainly due to the insecurity of property rights to mining sites (see Bohn and Deacon 2000).

[8] 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.

Figure 2 shows the distribution of artisanal mining sites across the Eastern DRC based on interactive maps created by the International Peace Information Service (IPIS) during 2008-2010, before Dodd-Frank was passed. This figure shows that gold and tin mines dominated the landscape and that coltan and wolframite sites were relatively rare, and Table 1 shows the underlying summary statistics.[9] 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 civilian miners.[10]

Table 2 summarizes information from IPIS maps about the presence of armed groups, and the interactions between miners and militia groups during 2008-2010, prior to Dodd Frank. Representative examples, from Spittaels and Hilgert (2008, 2010), include the following:

- 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"
- "Receive 500 FC from each miner on Thursdays and Fridays; …extort minerals from miners that are returning from the mines; …commit physical harassment."

B. 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.[11] 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 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

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[9] Of the identified mining sites, 63 percent were primarily gold mines and 32 percent were primarily cassiterite (tin). Only 3.5 percent were primarily coltan (tantalum) mines and 1.5 percent were primarily wolframite (tungsten).

[10] The minerals are transported to buyers located in the border cities 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).

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

the tin, tungsten, tantalum (i.e., the "3Ts") or gold.[12] The rules require companies to conduct "due diligence" on the origin of minerals; if the origin is from the DRC conflict mining zones then companies must report on the possibility that warlords have benefitted from the purchases by following the supply chains of minerals (KPMG 2011).

The Dodd-Frank Act was signed into law on July 21, 2010 (see figure 3). Although the Act did not prohibit the purchase of minerals from the DRC, many observers say it acted as a swift de facto boycott of minerals from the DRC (Pöyhönen et. al. 2010, Seay 2012). 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 – 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).

Probably as a response to Dodd-Frank, the DRC also imposed a governmental ban on artisanal mining and trade in artisanal mined minerals on September 11, 2010.[13] The ban 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 (from both the ban and Section 1502 de facto boycotts) because it is so easily concealed and smuggled when compared to the 3Ts (De Koning 2011, United Nations 2011). The ban was lifted on March 10, 2011, shortly before the international EICC boycott took hold (De Koning 2011).

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 significantly declined (Wimmer and Hilgert 2011, Geenan 2012). Official data on exports reveals a large drop in exports of tin, coltan, and wolframite during 2010 and 2011. Figure 4, Panel A shows the decrease in tin exported from North Kivu and South Kivu, the main tin producing territories of the DRC. Official exports dropped significantly despite the increase in world tin prices during 2010-2011 (see figure 8). Panel B shows official gold exports from

[12] The 3Ts and gold are used in a variety of industries including electronics, automobiles, medical equipment, aerospace, and jewelry (KPMG 2011).

[13] DRC's President stated the ban's goal was to weed out "mafia groups" from the mining industry. Many observers think the ban was a response to international pressure to stop trade in conflict minerals (Geenan 2012, Seay 2012).

Maniema (the only province for which we have found systematic data). Unlike 3Ts, exports of gold increased during 2010-2011 relative to 2008-2009, suggesting a shift towards gold mining.

Panel C shows monthly export data of tin from North Kivu. Official exports went to zero during the ban. Stockpiles were exported in March 2011, during a window of time between the end of the mining ban and the April 1, 2011 deadline that western companies had set to stop buying 3T minerals from smelters lacking traceability systems.[14] Chinese companies continued to buy 3T minerals from eastern Congo but at prices discounted of "up to 80 percent compared to world market valuations" (Carisch 2012, 15, see also Johnson 2013). By contrast, there is no evidence of major reductions in gold production "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

With this background in mind, we present a stylized theoretical framework to guide the empirical analysis. The simple framework is intended to capture the essence of Olson's (2000) stationary bandit idea and theories of the protection and intimidation functions served by organized criminals (Skaperdas 2001). In order to focus on short-run policy impacts, we fix the amount of warring capital held by armed groups and describe the conditions under which it will be 'stationed' at mining sites for the purpose of taxing mining labor. Focusing on a two-period planning horizon, we explain how the policies could disrupt a "stationary bandit" equilibrium, triggering an increase in violent conflict.

A. Labor and Mineral Extraction

We imagine a landscape containing three regions: an agricultural region (A) and two artisanal mining regions. The mining regions contain one of two different minerals, with $i = G$ (for gold) or C (for cassiterite).

There is a fixed number of homogenous civilian laborers, L, who work in one of the regions such that $L = L_A + L_G + L_C$. The wage in agriculture is fixed at w, and is effectively a subsistence wage. Artisanal mining technology is such that the quantity extracted, Y_i, increases

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

with the number laborers but at a decreasing rate so that $dY_i / dL_i > 0$ and $d^2Y_i / dL_i < 0$. To simplify exposition, we assume $Y_i = \sqrt{L_i}$ and ignore any dynamic depletion of the mine. The per laborer return is denoted by $p_i\sqrt{L_i} / L_i - \tau_i$ which we rewrite as

$$(1) \quad \frac{p_i}{\sqrt{L_i}} - \tau_i .$$

The variable $p_i > 0$ is the price per unit of output and $\tau_i \geq 0$ is the per-miner tax.

B. Militia Groups

There are several armed groups in the Eastern DRC but we assume *G*=2 for simplicity.[15] Each group has a fixed amount of armed soldiers and guns. This armed capital is specialized towards war-making and looting civilians and is useless for mining. If the two groups battle one another, the probabilities of victory are determined by relative size and known ex ante, for example $P(G_1 \text{ defeats } \mathrm{G}_2) = G_1/(G_1 + G_2)$, and $P(G_2 \text{ defeats } G_1) = G_2/(G_2 + G_1)$.

Each militia group ultimately chooses to deploy their soldiers into one of two mutually exclusive activities: either looting civilians or taxing miners.[16] Battles between the armed groups occur only to the extent that the two groups seek control over the same mining region. The maximum value to an armed group of taxing a mining region is given by

$$(2) \quad V_i^{TAX} = \sum_{t=0}^{T} \rho_i^t [\tau_i^* L_i^* (p_{i,} w,\ \tau_i^*)].$$

Here *T* represents the planning horizon, τ_i^* is the revenue-maximizing tax on each laborer, L_i^* is the number of laborers, and ρ is the militia's discount factor, with $0 < \rho < 1$.[17]

[15] According to the MiMiKi and Hinterlands maps, *G= 6* different groups but each group has multiple commanders that may be somewhat autonomous in practice.

[16] We assume the agricultural region is not taxed, which is consistent with the empirical observation that agriculture is typically not taxed in the eastern DRC. Taxing agricultural laborers may not be feasible because agricultural land is relatively abundant and homogenous such that farmers could simply relocate away from taxing militia groups to avoid taxes.

[17] We assume that militia groups tax labor rather than output because the IPIS data described in section 2 indicates that labor taxes were typically used at militarized mining sites, whether gold or tin. In some presentations of discounting, including those in natural resource economics, it is assumed that $\rho = 1/(1+\delta)$ where $\delta > 0$ is the discount rate (see, e.g., Conrad 2010).

A mining region is secured for taxing if two conditions hold: 1) the armed group has stationed its soldiers in the mining region and 2) it is not engaged in battle with the other armed group.[18] Stationing armed soldiers at mining sites eliminates unobserved mineral extraction and it enables 'protection' of miners. We assume that neither group has sufficient armed soldiers to secure both mining regions.

C. Stationary Bandit Equilibrium

The system is in a stationary bandit equilibrium if each militia group is 'stationed' in a separate mining region, taxing labor, and neither group could gain expected revenue by looting civilians, or by challenging the other armed group for control over the other mining region. If we assume that is L large enough to dissipate mining rents earned by labor, then a stationary-bandit equilibrium dictates that labor will enter each mining region until after-tax revenue per laborer equals the agricultural wage such that

$$(3)\quad \frac{p_i}{\sqrt{L_i}} - \tau_i = w \quad for\ i\ =\ G,\ C.$$

The equilibrium tax revenue is given by

$$(4)\quad \tau_i^* L_i = \tau_i^* \left(\frac{p_i}{w + \tau^*} \right)^2.$$

Solving for the revenue-maximizing tax rate, which necessarily considers the reaction by labor, we find $\tau^* = w$. Thus, equation (4) can be rewritten as

$$(5)\quad \tau_i^* L_i = \frac{p_i^2}{4w}.$$

In a stationary-bandit equilibrium, labor is distributed as in (6), all laborers earn a subsistence wage, and there is not violence.

$$(6)\quad L_G = \frac{p_G^2}{4w^2};\ L_C = \frac{p_C^2}{4w^2};\ L_A = L - \frac{p_G^2 + p_C^2}{4w^2}.$$

D. Incentives to Loot and Rove

[18] These conditions are related to the conditions for secure 'ownership' of any economic asset (see Barzel 1997). Similar 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, Umbeck 1977, La Croix 1992, and Libecap 2007).

We now consider the payouts to an armed group from looting and roving, assuming the stationary-bandit equilibrium as a starting point. To be more concrete, we assume Group 1 is initially in control of and taxing the cassiterite (tin) region and Group 2 is initially in control of and taxing the gold region. We focus on Group 1's incentives and consider Group 2 only in the context of how it will respond to the actions of Group 1.

Figure 5 illustrates Group 1's incentive to loot in a one-period model. If Group 1 chooses to loot, by violently taking the subsistence earnings from tin miners, it accrues the one-time revenue earned in the tin mining region of

$$(7)\quad p_C Y_C = p_C \sqrt{L_C(p_{C,} w, \tau_C^*)} = \frac{p_C^2}{2w} \ .$$

This revenue is twice the per-period revenue Group 1 could extract by taxing (equation 5). Hence, it would never be optimal for Group 1 to tax if $T = 1$.

There is a cost to looting the mine when Group 1's planning horizon is two periods. We assume a mining region will be unproductive in t =1 if it was looted in t = 0 (because the looting event is violent and harms the labor force).

Figure 6 illustrates the decisions and payouts to Group 1 (G1) when it has a two-period planning horizon. If Group 1 taxes in t =0, then its soldiers remain stationed in the tin mining region through t =1. It will always be optimal for Group 1 to use those stationed soldiers to loot the tin mine during t = 1, because it is the final period.[19] The discounted revenue from taxing the mine in t =0 is therefore $(1+2\rho)\frac{p_C^2}{4w}$, the 'stationary path' revenue.

If Group 1 loots the tin region during t = 0, then its soldiers are free to rove and will either loot the agricultural region or battle for the right to loot the gold region in t =1. Consider first the payout from the 'looting path', which is $\frac{p_C^2}{2w} + \rho\alpha w L_A$. The variable $0 \le \alpha < 1$ refers to the proportion of agricultural revenue that Group 1 can loot with its endowment of armed capital. The variable α is fixed and we imagine it to be small, because agriculture is spatially diffuse relative to mining. The term wL_A represents agricultural revenue where $L_A = L - \frac{p_G^2 + p_C^2}{4w^2}$ in period t – 1. To simplify, we assume labor is not mobile in or out of regions during the two-

[19] The planning horizon resets after t =0, however, so the final period of looting would never actually be reached.

period planning horizon; laborers makes location decisions based on the militia behavior in period t - 1.

Given these assumptions, a sufficient (but not necessary) condition for Group 1 to loot the tin mine in t=0 is $(1+2\rho)\frac{p_C}{4w} < \rho\alpha w L_A$, which we rewrite as

(8) $$\rho\left(2-\alpha L_A\frac{4w^2}{p_C^2}\right)<1 .$$

Comparative statics of (8) indicate that looting is more likely with an increase in w, or with a decrease in p_C or ρ.

The attractiveness of the 'loot and battle' path to Group 1 depends on how Group 2 would respond to the observation of Group 1's looting in t = 0. If Group 2 would respond by looting the gold region in t =0, then Group 1 would have no incentive to battle for the gold region. We explain the conditions under which Group 2 will respond by looting shortly.

If Group 2 would remain stationed to defend the gold region in t = 1, then the expected revenue to Group 1 of the 'loot and battle' path is $\frac{p_C^2}{2w}+\rho\pi\frac{p_G^2}{2w}$. The notation π refers to $P(G_1 \text{ defeats } G_2)$. Conditional on Group 2 staying to fight, Group 1 prefers the 'loot and battle' path to the 'stationary path' when $(1+2\rho)\frac{p_C^2}{4w} < \frac{p_C^2}{2w}+\rho\pi\frac{p_G^2}{2w}$, which we rewrite as

(9) $$\pi\frac{p_G^2}{p_C^2}+\frac{1}{2\rho}>1.$$

Comparative statics of (9) indicate the 'loot and battle' path becomes more attractive to Group 1, relative to the 'stationary path', as the relative price of gold rises and the discount factor falls.

Again, conditional on Group 2 staying to fight, Group 1 prefers the 'loot and battle' path to the 'looting path' when $\frac{p_C^2}{2w}+\rho\pi\frac{p_G^2}{2w} > \frac{p_C^2}{2w}+\rho\alpha w L_A$, which we rewrite as

(10) $$\pi p_G^2 > 2\alpha w^2 L_A .$$

Holding constant π, comparative statics of (10) indicate the 'loot and battle' path becomes more attractive to Group 1, relative to the 'looting path', as the price of gold rises.

However, the 'loot and battle' path is feasible only if Group 2 remains stationed in the gold region during t =1 to defend it rather than looting the gold region in t = 0. Group 2 will remain stationed if $(1+2\rho(1-\pi))\frac{p_G^2}{4w} > \frac{p_G^2}{2w}+\rho\alpha w L_A$, where $1-\pi = P(G_2 \text{ defeats } G_1)$. Rewriting, Group 2 will stay stationed and tax in t =0 if

(11) $$\pi \le 1-\frac{1}{2\rho}-\frac{2\alpha w^2 L_A}{p_G^2}.$$[20]

Comparing (9), (10), and (11) indicates that, although a larger π raises the expected payout to Group 1 of the 'loot and battle' path - conditional on Group 2 staying to fight - a larger π simultaneously lowers the probability that Group 2 will stay to fight. Rewriting, we note that battle over the gold region will occur if conditions (12) and (13) both hold.

(12) $$\left(1-\frac{1}{2\rho}\right)\left(\frac{p_C}{p_G}\right)^2 < \pi \le 1-\frac{1}{2\rho}-\frac{2\alpha w^2 L_A}{p_G^2}.$$

(13) $$\frac{2\alpha w^2 L_A}{p_G^2} < \pi \le 1-\frac{1}{2\rho}-\frac{2\alpha w^2 L_A}{p_G^2}$$

An increase in the price of gold increases the probability that conditions (12) and (13) will hold. A decrease in the price of tin, p_C, raises the probability that (12) will hold and has no effect on (13). If there are large asymmetries in the power of the two militia groups, then battles will be induced only by large charges in mineral prices. Asymmetry in military power helps bind the stationary-bandit equilibrium.[21]

E. Effects of the Mining Policies on Conflict

We hypothesize that Dodd Frank and the mining ban broke down a stationary bandit equilibrium for several complementary reasons. First, the policies sharply lowered the local price of minerals, particularly tin, tantalum and tungsten (see section 2). In our theory, a decrease in p_C makes looting agriculture relatively more attractive than taxing tin and thus raises the probability of looting and roving (see equation 8).

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[20] We assume that ρ and α are the same for both armed groups.

[21] This result complements a large literature suggesting the probability of conflict in the absence of clear property rights – as opposed to cooperation - between opposing parties is higher when power is relatively symmetric (see, e.g., Umbeck 1981, Hirshleifer 1991, Skepardas 1991, Anderson and McChesney 1994, Skepardas 1991, and Ralston 2012). Similarly, the literature on the determinants of legal settlement versus litigation – which is a courtroom battle – contends that trials select from cases in which the two litigants have an equal chance of winning (see Priest and Klein 1984, Cooter and Rubinfeld 1989, Friedman and Wittman 2007).

Second, the policies caused the local price of tin (and presumably tungsten and tantalum) to fall much more dramatically than the local price of gold (see section 2). In our theory, a decrease in the relative price, p_C / p_G, raises the probability of battle over gold mines in t =1 (see equation 12).

Third, the policies made the future of artisanal 3T mining more uncertain, plausibly shortening the planning horizon of Group 1, or raising its discount rate. In our theory, a planning horizon of one-period rather than two-periods guarantees looting, and an exogenous decrease in ρ raises the probability of looting.

Adapting our theory to the real setting in the eastern DRC of multiple armed groups and multiple mines, motivates the following testable hypotheses:

H1. The 'conflict mineral policies' caused some armed groups that were stationed at 3T mines to abandon those mines and violently loot civilians near the sites.

H2. The 'conflict mineral policies' caused some armed groups that were stationed at gold mines to abandon those mines and violently loot civilians near the sites (in order to avoid battles with roving armed groups).

H3. The 'conflict mineral policies' increased the probability of battles between armed groups near gold mining sites.

4. Data for Empirical Analysis

To test 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 conflict data come from the Armed Conflict Location and Event Dataset (ACLED).[22] 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.[23] The ACLED data currently covers 1997-2012 for the DRC, but our analysis focuses on 2008-2011.

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

[23] We are aware of two other economic studies that employ DRC, ACLED data in empirical analyses. Maystadt et al. (2014) study the relationship between conflict and mineral prices during 1997-2007, and Pellillo (2011) uses the data to study the impact of conflicts on household assets. Maystadt et al. (2014) uncover a complex relationship

Focusing on the 2008-2011 period means that we analyze about 2.5 years of data prior to the Dodd-Frank Act, and 1.5 years of data after the Act. We begin the analysis in 2008, rather than earlier, because the IPIS surveys of mining sites (see section 2) were conducted from 2008 until early 2010, prior to Dodd Frank. Hence, 2008-2010 is the pre-Dodd Frank period for which we have precise data on the location of artisanal mining activities. We end the analysis in 2011, rather than 2012, because we are interested in measuring the short-run impacts of the policies and because a government army rebellion occurred in 2012 that we do not model. [24] As we note later, our empirical results are robust to analysis of the longer, 2004-2012 time period.[25]

The unit of analysis in the ACLED dataset is a "politically violent event" occurring on a specific date (day) and at a specific location (longitude and latitude). Battles or conflicts lasting multiple days are recorded as separate "atomic" incidents. This fact is important to keep in mind when interpreting the data. The ACLED coding of events includes battles, violence against civilians, riots/protests, and non-violent events. We drop riots/protests and non-violent events from our analysis because our theory is silent on their determinants. The ACLED data provides some information on the number of fatalities per event, but fatalities are often unknown or unreported, rendering the information unreliable for econometric analysis.

Because the raw ACLED data are available in a highly disaggregated form, we must choose if and how to aggregate the data spatially and temporally prior to analysis. 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, or of conflict, is not always known with precision. We drop from our analysis all territories in the six western provinces for which we lack data on the location of artisanal mines. We therefore focus our analysis on the $i = 70$ territories in the Eastern DRC (see figure 2). Temporally we focus our analysis at the monthly level, because our mineral price data can be observed at the monthly (but not daily) level, and because other researchers have followed this approach (see Maystadt et al. 2014).

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between mining starts and violence that depends on the spatial scale considered. Pellillo (2011) finds negative effects of violence near villages and the accumulation of assets in villages.

[24] The rebellion is described succinctly at www.bbc.com/news/world-africa-20438531.

[25] We do not include in our analysis the 1997 to 2003 period of the Second Congo War because our theory is silent on many of its complex determinants as described, for example, by Stearns (2011).

Figure 7 summarizes the ACLED data for the five eastern provinces of the DRC. There were 3,469 violent conflict events over 2004-2012, with 1,825 battles and 1,643 violence-against-civilians events. The number of conflicts was highest in 2012 (695), 2009 (625), and 2011 (605). Econometrically we employ monthly, territory-level conflict data over 2008-2011 which are summarized in Table 3 and in more detail in Table A1 of the appendix. On average there were 0.56 conflicts per month, ranging from zero to 57.

B. Policy Indicator Variable

Our empirical analysis employs a single 'policy indicator' variable that assigns 'treatment' over time and across the territories most directly affected by the mining policies. Although the use of a single indicator variable forgoes some detail about the timing of different policies (e.g., the passage of Dodd Frank in July 2010, the mining ban in September 2010, the EITC boycott in April 2011), this simple choice has advantages. Most importantly, it would be inappropriate to consider the policies following-up on Dodd Frank as separate and independent events when the passage of Dodd Frank almost certainly triggered the subsequent policies.[26]

We choose July 2010 as the time in which 'treatment' began, although we recognize that formal regulatory authority of Section 1502 was not exercised until later. Our choice of July 2010 is less arbitrary than other times we could choose, and it is reasonable for several reasons. First, Section 1502 would likely affect discount rates and planning horizons over mine control immediately, causing armed groups to react well before specific regulations were written, according to our theory.[27] Second, observers argued that Dodd Frank was causing a de facto boycott shortly after it was passed, well before the more official boycott began in April 2011 (Pöyhönen et. al 2010, Seay 2012). Third, the de facto boycott, and the mining ban that shortly followed, lowered the local prices of 3T minerals well before the formal boycott.

[26] 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."

[27] Section 1502 was added to Dodd-Frank late in the legislation process, between May 2010 and July 2010, so a treatment date preceding July 2010 by more than a month or two would not be appropriate.

For the spatial dimension of policy treatment, we designate a 'treated' group of territories to correspond with our conceptual landscape, which includes a gold mining region, a tin mining region, and an agricultural region (see section 3). We designate as 'treated' the intersection of the territories for which mining was banned (i.e., all territories in Maniema, North Kivu, and South Kivu) and the territories that the U.S. State Department identified as being exploited by armed groups as part of its role in complying with Section 1502.[28] There are 27 'policy territories', which are illustrated as the shaded territories in figure 2.

The 27 policy territories consist of 19 territories that had militarized artisanal mines during 2008-2010, prior to Dodd Frank, and 8 territories without such mines. The 8 territories lacking mines corresponds to our theoretical 'agricultural region', which is lootable but not taxed by militias. Within the 19 policy territories having mines, some of these territories specialized in 3T mining prior to Dodd Frank (corresponding to the 'tin mining region'), and other territories specialized in gold mining (corresponding to the 'gold mining region'). The remaining 43 'non-policy' territories in the five eastern provinces comprise the control group of territories.

Given or temporal and spatial designation of treatment, the policy indicator takes a non-zero value for 486 observations in our main regressions. (This is 27 territories x 18 months from July 2010-December 2011). The policy indicator variable equals 0.33 during July 2010, because Dodd Frank was not passed until July 21, 2010.

C. Mineral Prices

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

Figure 8 shows the monthly averages for 2004 – 2012, which are CPI adjusted and reported in U.S. dollars. Of the four minerals, gold has experienced the most consistent increase in price, reaching $1648 per ounce by the end of 2011. The price of tin has fluctuated since 2004, reaching a high of $14.77 per pound in April 2011. The price of tungsten (from wolframite) spiked in 2005 and stayed high until 2008. It rebounded with a world price of $22.95 per pound

[28] The exploited areas are depicted in a U.S. Dept. of State map, which is unclassified and publicly available. See https://hiu.state.gov/Products/DRC_MineralExploitation_2011June14_HIU_U357.pdf.

in December 2011. The price of tantalum (from coltan) started to rise in the beginning of 2010, and was $180 per pound in December 2011.[29]

D. Rainfall Shocks

In our theory, positive wage shocks in agriculture raise the incentives for armed groups to loot the agricultural region. To proxy exogenous wage shocks, we have followed Maystadt et al. (2014) by constructing a measure of territory-level rainfall anomalies. Like Maystadt et al., we assume that abnormally high – but not excessively high – quantities of rainfall act as positive wage shocks in the largely unirrigated agricultural regions of the eastern DRC. To construct the rainfall measure, we first downloaded precipitation data from Global Precipitation Climatology Center's (GPCC) website and then converted the monthly, spatially gridded data to territory-level averages using a process we describe in an appendix. Next, we calculated rainfall anomalies for each territory-month observation. Anomalies are the difference between rainfall during the specific month and the territory's 1951-2012 (61 year) mean for that particular month. We divided the difference by the standard deviation in rainfall over 1951-2012 to standardize. The resulting variable has a mean of 0.063 and ranges from -2.66 to 3.59 (see Table 1).

5. Empirical Analysis

Our theoretical framework hypothesizes that the mining policies triggered an increase in violence against civilians within the policy territories, both near mines and in the surrounding agricultural territories. The framework also hypothesizes that the mining policies triggered battles between militia groups, but only near gold mining sites. We present tests in this section, after first presenting graphical evidence.

A. Graphical Evidence

Figure 9 shows initial, visual evidence. Focusing first on Panel C, we see that violence against civilians in the 27 policy territories began to rise sharply at the end of 2010, after the

[29] 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.

passage of Dodd Frank, and stayed high through much of 2011 and 2012. As Panel D indicates, there was not a commensurate rise in violence against civilians in the 43 non-policy territories.[30] Figure 9 also shows that the number of monthly battles in the policy and non-policy territories over 2004-2012. In Panel F, we see that the number of battles increased in the policy territories after Dodd Frank was passed, at least relative to the number of battles in the non-policy territories post-Dodd Frank.

Figure 10 plots conflict events over a shorter window of time, from 2008-2011. Panels C and D separately plot incidents of conflict in the 19 policy territories with mines prior to Dodd Frank, and the 8 policy territories without mines. Panel C indicates that mining and non-mining territories had similar levels of violence against civilians prior to Dodd Frank and this type of conflict was following similar, relatively flat, trajectories during 2008 to July 2010 in both sets of territories. Violence against civilians increased after Dodd Frank in both sets of territories, but the increase was relatively pronounced in territories with mines. Panels E and F plot conflicts based on whether the territories specialized in 3Ts or gold artisanal mining prior to Dodd Frank. Panel E indicates that violence against civilians increased sharply in both types of territories after Dodd Frank, with small increases first occurring in the 3Ts mining territories and larger increases occurring shortly thereafter in the gold mining territories. Panel F shows that battles were infrequent in both types of territories during mid-2009 until early 2011 when the number of battles increased sharply in the gold mining but not 3Ts territories.

In summary, the visual evidence in Figures 9 and 10 suggests the conflict mineral policies increased conflict in ways consistent with our theoretical reasoning. Violence against civilians rose sharply in the territories directly affected by the policies after Dodd Frank was passed, but actually fell in other territories of the eastern DRC. Visually, the increase in violence against civilians was relatively pronounced in policy territories having mines. Moreover, the post-Dodd Frank increase in battles occurred primarily in territories with only gold mines, as there was not a detectable rise in the number of battles in territories specializing in 3Ts mining after Dodd Frank.

B. Regression Analysis

[30] If Dodd Frank policies caused spatial spillover of violence into the non-policy territories, then these comparisons are biased downward and understate the true effect of the policies. In the short-run, (e.g, July 2010- Dec. 2011) this is less of a concern than the longer run (e.g., July 2010- Dec. 2012).

We now test for the policy effects using regression analysis. Our least restrictive regression model is of the form in (14), but we begin by estimating a baseline regression in which all coefficients except δ_i, μ_t, and β are zero.

$$\text{(14)} \quad \begin{aligned} conflicts_{it} &= \delta_i + \mu_t + \beta(policy\ ind)_{it} + \sum_{m=1}^{4} \lambda_m (mine\ type_{i,m} \times mine\ price_{t,m}) \\ &+ \eta(rain)_{it} + \sum_{x=1}^{5} \alpha_x conflict_{i,t-x} + \sum_{q=1}^{2} \phi_q adj.\ conflict_{i,t-q} + \varepsilon_{it} \end{aligned}$$

Here i=the 70 territories and t = the 48 months spanning 2008-2011. The notation δ_i represents the 70 territory fixed effects and μ_t represents the 48 time effects. 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, fractionalization, and geography (see Esteban et al. 2012). The time period effects control for eastern DRC-wide factors that may cause changes in conflict, such as presidential elections or changes in national inflation.

Although our outcome variables are count data, we employ OLS linear fixed effects estimators. We justify this choice on technical and practical grounds. On the technical side, we are reluctant to make assumptions about the distribution of the error terms in order to validate Poisson or Negative Binomial estimators. On the practical side, we are confident that our main inferences are not sensitive to estimator choice. For example, our baseline regression results are robust to the use of Poisson or negative binomial estimators, and the main results are robust to the use of Linear Probability Model (LPM) fixed effects estimates of conflict indicator variables (see appendix table A3). In all of our estimates, we cluster standard errors at the territory level to account for possible serial correlation within territories (Bertrand et al. 2004).

Columns 1-3 of Table 4 show the coefficient estimates of the Conflicts, Civilians, and Battles outcomes. The policy indicator is positively associated with increased conflict, with a coefficient of 0.69. For perspective, the mean number of conflicts during 2008 to July 2010 was 0.66 in the policy territories. The coefficient of 0.69 therefore implies a 105 percent increase in the incidence of conflict. The policy indicator is also positively associated with violence against civilians, with a coefficient estimate of 0.58 relative to a 0.22 mean during 2008 to July 2010, implying a 263 percent increase. By contrast, the policy indicator coefficient in column 3 is not significantly associated with incidence of battles.

The baseline regressions do not control for world mineral prices, or climate shocks, which seem a glaring omission in a study of conflict and natural resources. Indeed, commodity prices and agricultural wages are part of our theory in section 3, and are the key focus of many papers that study whether or not increases in natural resource prices and favorable climate shocks lead to more conflict (see, e.g., Collier and Hoeffler 2004, Miguel et al. 2004, Miguel 2005, Angrist and Kugler 2008, Brückner and Ciccone 2010, Bohlken and Sergenti 2011, Hsiang et al. 2011, Dube and Vargas 2013, Maystadt et al. 2014, de la Sierra 2014). Moreover, figure 8 makes it clear that world prices of tin, tungsten and tantalum (but not gold) spiked at the beginning of 2011, which is when conflict incidences also spiked in the policy territories (see figures 9-10). The omission of price controls in the baseline, therefore, could be biasing the policy indicator coefficients.

There are problems with including world mineral prices in our regressions, however. First, as discussed in section 2, the local price received by miners and traders in the wake of Dodd Frank may bear little resemblance to the world price. As figure 8 shows, the world prices of tin and gold were rising when the prices received locally were falling. Second, Dodd Frank may have caused increases in the world prices of some conflict minerals, particularly tantalum and tungsten.[31] With this caveat in mind, in columns 4-6, we control for world mineral prices by interacting mineral price interactions with mining site indicators (see table 3). In terms of the regression model in (14), we allow λ_1, λ_2, λ_3 and λ_4 to be non-zero. We also include in columns 4-6 our measures of rainfall shocks to proxy for shocks to the wage earned in agriculture as described in section 4.[32] In terms of the regression model in (14), we allow η to be non-zero.

As the results in columns 4-6 indicate, controlling for world prices and rainfall anomalies has minor effects on the statistical and economic significance of the policy indicator variable. The price-mine interaction terms themselves are generally negatively related to violence against civilians, but insignificant, except for the tungsten interaction, which is consistently negative and

[31] Media articles claiming a causal relationship between the conflict mineral policies and the prices of tantalum can be found at www.resourceinvestor.com/2012/02/10/dodd-frank-australian-cuts-threaten-tantalum. Media articles on the relationship between mineral polices and tin prices can be found at www.resourceinvestor.com/2010/11/09/tin-prices-jump-as-congo-embargo-foreseen.Media articles on the relationship between mineral policies and tungsten supply can be found at www.ctia.com.cn/TungstenNews/2011/78166.html.

[32] Weather shocks are related to the incidence of civil conflicts at the global scale (see Hsiang et al. 2011), and with violence in settings ranging from murder in Tanzania (Miguel 2005) to riots in India (Bohlken and Sergenti 2011).

statistically significant. The negative coefficients on the price-mine interactions are not inconsistent with our theory, which predicts that increases in prices raise the incentives for armed groups to station themselves by mining sites to tax rather than rove and loot. The lack of significant impacts may mean that monthly price changes are too subtle and fleeting to trigger detectable changes in violence.

The coefficients columns 4-6, and throughout Table 4, show that rainfall anomalies are positively related to conflicts in most specifications. This rainfall effect is driven more so by increases in battles, rather than by increasing violence against civilians, which is the channel our theory hypothesized.[33] Generally, this finding suggests that militia groups are more willing to battle over agricultural surpluses as those surpluses increase, which is a rapacity effect. However, the rainfall estimates are not robust to the use of LPM fixed effects estimator of conflict indicator variables (see Table A3), so we are reluctant to draw conclusions about the relationship between rainfall anomalies and conflict in our setting.

In columns 7-9 of Table 4, we follow the lead of other empirical studies, including Esteban et al. (2012), and control for the local persistence of violent events by including lags for the number of conflicts in previous periods.[34] We also control for the lagged number of conflicts in adjacent territories. In the context of regression equation (14), we allow α_x and π_q to be non-zero. We include lags until they are no longer statistically significant in any specification or robustness check that we have tried, which occurs at x = 5 month lags for lagged conflict and q = 2 month lags for adjacent territory conflict. As the results indicate, lagged conflicts are important predictors of contemporary conflict. The inclusion of lags also diminishes the size of the policy indicator coefficients on Conflicts and Civilians, but both coefficients remain statistically significant.

The statistical significance of the lagged variables lasting up to four months raises concerns that the policy indicator coefficients could be inflated upwards because of conflicts that may have begun prior to the policies, and then temporally spilled over into the policy periods. In

[33] The marginal effects of rainfall anomalies on conflict are declining as the magnitude of rainfall anomalies increase, as indicated by the negative sign on the rainfall anomaly squared variable. This is not surprising. Like Maystadt et al. (2014), we suspect that above average rainfall increases agricultural earnings in the eastern DRC but flooding does the opposite.

[34] These controls for lagged conflict are particularly important in the context of ACLED data because extended conflicts are counted as separate incidents for each day they persist (see table 1).

columns 10-12, we include policy territory *x* month interactions for each of the five months preceding Dodd Frank. The coefficients on these pre-policy placebo variables are statistically insignificant, suggesting there was not a run-up in conflicts in the months preceding Dodd Frank.

To summarize, the Table 4 evidence suggests the conflict mineral policies increased overall conflicts, and the incidence of violence against civilians. These findings hold when the time period is expanded to 2004-2012 (see table A2), when the outcome variable is an indicator of monthly conflict rather than a count variable (see table A3), and when we interact mineral prices with the number of mines in a territory rather than with an indicator for the presence of mines (see Table A4).

Table 5 presents tests that allow the effect of the policies to vary within the policy territories. In columns 1 and 2, we interact the policy indicator variable with an indicator variable for the 19 territories that had militarized artisanal mines prior to Dodd Frank. In column 1 the dependent variable is the incidents of violence against civilians. In this column, the coefficient on the policy indicator is positive but the coefficient on interaction term is not statistically significant. Hence, the evidence suggests that Dodd-Frank increased violence against civilians in mining and agricultural territories to a statistically equivalent extent.

In column 2 of Table 5 the dependent variable is the incidents of battles. In this case, only the interaction term is significant. Its positive sign suggests that Dodd Frank increased the incidence of battles, but only in mining territories.

In columns 3 and 4 of Table 5 we further differentiate the effects of the policies by interacting the policy variable with indicators for the presence of 3T or gold mines in a territory prior to Dodd Frank. Focusing on column 4, the positive and significant interaction term on the policy *x* gold mine indicator variable provides evidence that Dodd Frank triggered militia battles over gold mining sites but not over 3T sites. This policy effect is predicted by our theoretical model.

Finally, in columns 5 and 6 we present tests using a subsample of data that omits territories that had both 3T and gold artisanal mines prior to Dodd Frank. Hence, the sample of policy territories here includes only those territories that specialized in either gold or 3T mining as depicted in Panels E and F of Figure 10. The results in columns 5 and 6 mimic the results of column 3 and 4. Dodd-Frank and the related policies appear to have caused a general rise in violence against civilians that was not specific to mining regions, but a targeted rise in battles over gold mining territories. These results are consistent with our theoretical framework which hypothesizes that the policies caused militia groups to loot civilians and rove, and to battle for the relatively more valuable gold mining sites.

C. Discussion and Connection to Related Empirical Findings

Our empirical findings are reinforced by anecdotal evidence on the effects of Dodd Frank and the mining ban, and by other research about mining, conflict, and shocks to mineral prices in the eastern DRC. With respect to anecdotal evidence, there is qualitative information about what happened at Bisie, the largest artisanal tin mine in North Kivu. Prior to Dodd Frank and the ban, Bisie was home to about 13,000 people including 3,000 miners who were able to keep about 50 percent of the cassiterite mined and were taxed for the remainder by militia groups. Shortly after the imposition of the policies, 1200 miners left for the nearby town of Ndjingala, and most remaining 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 Bisie 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 (the government military group) taking control of small gold mining sites in the Kivus and Maniema that were formerly occupied by smaller militias after the conflict mineral policies (see United Nations 2011, Carisch 2012).

Our empirical findings also complement those of Maystadt et al. (2014) and de la Sierra (2014). Maystadt et al. (2014) find a robust relationship between new mining concessions in the DRC during 1997-2007 and violent conflict, suggesting there is a resource curse at work. However, they find that clusters of mining sites tend to push conflict further from mining sites, as armed groups seek to ensure that production is not disturbed by nearby violence, which is similar to our reasoning. Maystadt et al. do not study how conflict varies by mine type, and their analysis concludes before the time period we study. Our findings are also generally consistent with de la Sierra (2014), who finds that armed groups violently established themselves at coltan mining villages, and asserted taxes, following a sharp rise in coltan prices during the early 2000s. Like us, his paper examines the decision by armed groups to become stationary bandits, but, in his study the decision is motivated by price shocks rather than the specific policy shock we examine.

Finally, our findings also contribute the ongoing policy debate about Section 1502. Whereas journalists and local observers have accused the law of exacerbating poverty, unemployment, and violence in artisanal mining regions (see Aronson 2011, Sematumba 2011, Pöyhönen et. al. 2010, Sematumba 2011, Seay 2012), advocacy groups such as the Enough Project have continued to defend Section 1502 as doing more good than damage.[35] For example, the Enough Project appears to regard the drop in local 3T prices as an indication of the success of Dodd Frank, claiming that the drop in prices has "helped lead to a 65% drop in armed groups' profit from trade in tin, tantalum, and tungsten – the 3Ts – over the past two years" (Johnson 2013, p. 53). This is a stark contrast with our logic and empirical findings, suggesting that the Section 1502 triggered decline in local prices of the 3Ts and shock to militia planning horizons and discount factors has likely caused wave of violence against civilians in the eastern DRC.

6. Conclusions

The top-down decisions to ban artisanal mining in three eastern DRC provinces and to regulate companies using those minerals did not reduce conflict during the time period we study. The long term effects remain to be seen, but the short term effects appear to have been devastating for some Congolese civilians. Instead of reducing violence, our findings suggest the policies have increased the number of armed conflicts in the eastern DRC, particularly against civilians, whom the policies were specifically designed to protect.

Our results and approach contribute to the literature on the interaction between natural resource prices, endowments, and violence. We join others in concluding that the resource curse, as it pertains to violent conflict, is a complex phenomenon that is unlikely solved by international trade embargoes or boycotts that reduce the value of a country's natural resource endowment.[36]

[35]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." 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.

[36] Several recent studies cast doubt on the generalization that resource endowments are the cause of violence in conflict ridden countries (see, e.g. Miguel and Bellows 2009, and Brunnschweiler and Bulte 2009, Rigterink 2014).

We also offer a different theoretical premise – that of stationary and roving bandits - from which to analyze armed civil conflict rather than modeling rapacity versus opportunity cost effects. Under the bandit premise, civilians pay taxes to armed thugs in exchange for a crude form of protection. This informal institutional arrangement is not first best, of course, but it may be safer and more economically productive than anarchy (see Hirshleifer 1995, Skaperdos 2001, Olson 2000). Policy-makers should at least be aware of this possibility when considering whether or not to intervene in ways that affect informal property rights, and power relationships, in foreign land.

To be clear, our theoretical approach does not imply that opportunity cost and rapacity effects are unimportant in our setting. On the contrary, some commentators have argued that the Dodd Frank boycott created incentives for young men to join militias (see Pöyhönen et. al. 2010, 26), which is an opportunity cost argument. Moreover, our finding that violence shifted towards gold mining territories is fundamentally a rapacity effect (because violence shifted to the more valuable resource). Focusing on these tradeoffs alone, however, would cause us to miss insights about how changes in the value of natural resources change informal claims to property, and relationships between powerful and powerless people.

Finally, we have focused on the short-run impacts of Dodd Frank but an examination of the longer run impacts could be fruitful. As other economists have suggested, reducing the flow of revenue from mineral trade to illicit militias could have the important effect of reducing their stock of weaponry (see Janus 2011, Collier and Hoeffler 2004), which some advocacy groups claim has already happened. A reduction in militia weaponry will not necessarily reduce violence in the longer run, however. The reduction could actually raise the probability of battles between militia groups if, for example, the decrease in weaponry led to more symmetry in the strength of competing militia groups and hence greater willingness to fight (see Ralston 2012). These important possibilities are beyond the scope of our paper, but we hope they are addressed by future research.

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Figure 1: Provinces of the Democratic Republic of Congo

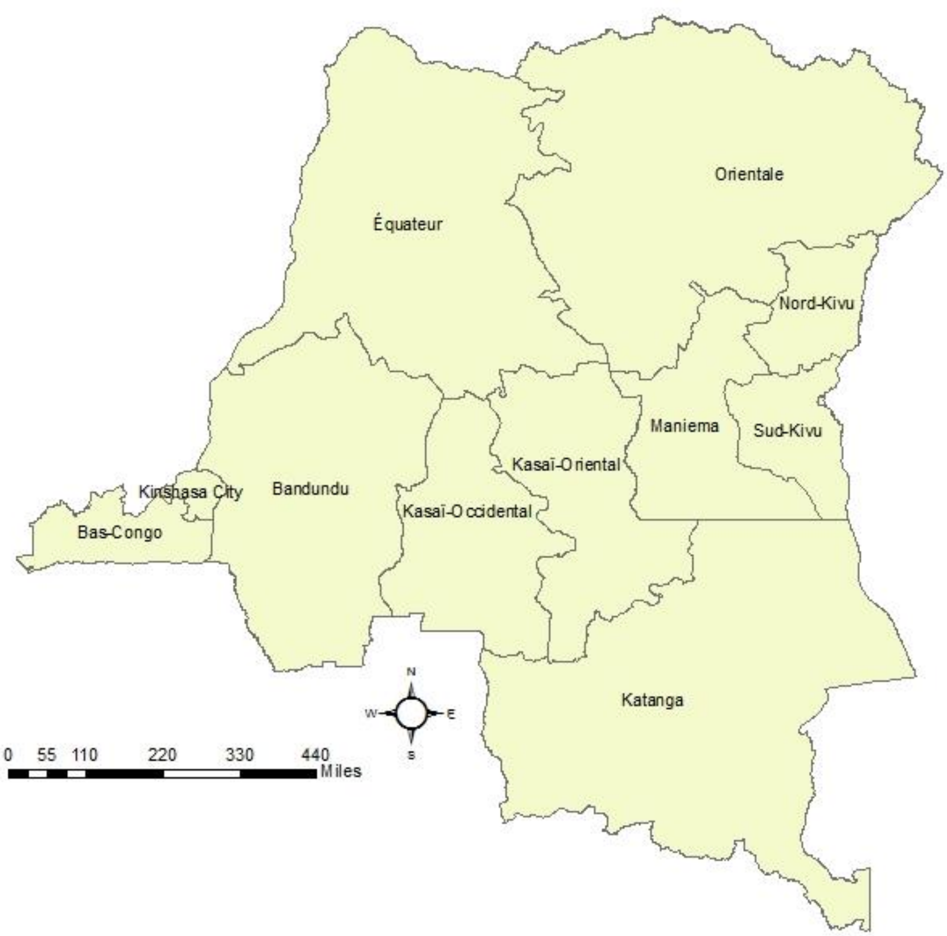
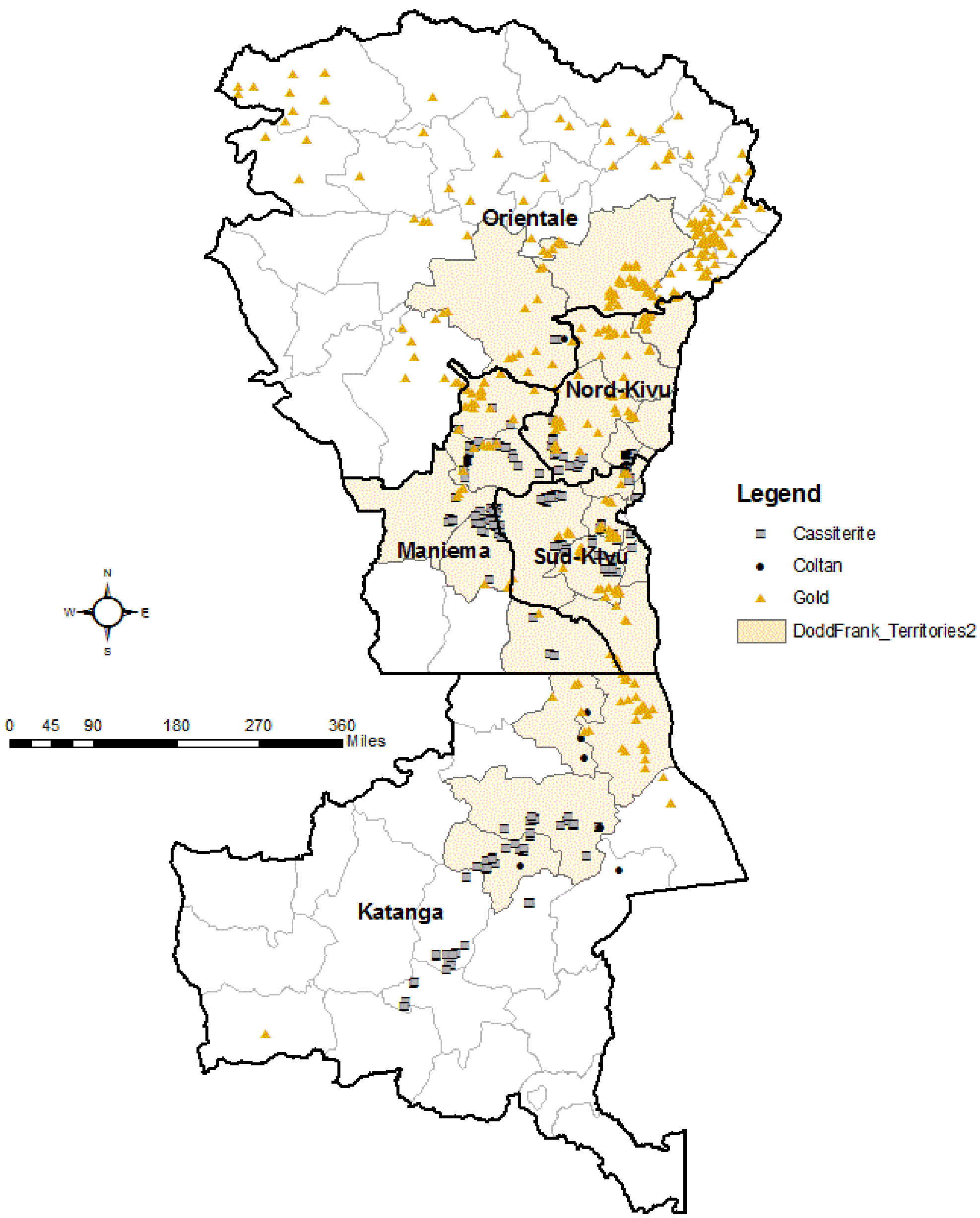


Figure 2: Artisanal Mining Sites in the Eastern DRC



Notes: The mining ban territories are Maniema, North Kivu, and South Kivu.The shaded territories are those with the militarized mining areas as described in the MiMiKi and Hinterlands' maps created during 2008-2010. The shaded territories appear on the U.S. State Department's map, in compliance with Section 1502. The map has been declassified and is available at: https://hiu.state.gov/Products/DRC_MineralExploitation_2011June14_HIU_U357.pdf.

Figure 3: Timeline of Key Mineral Regulations

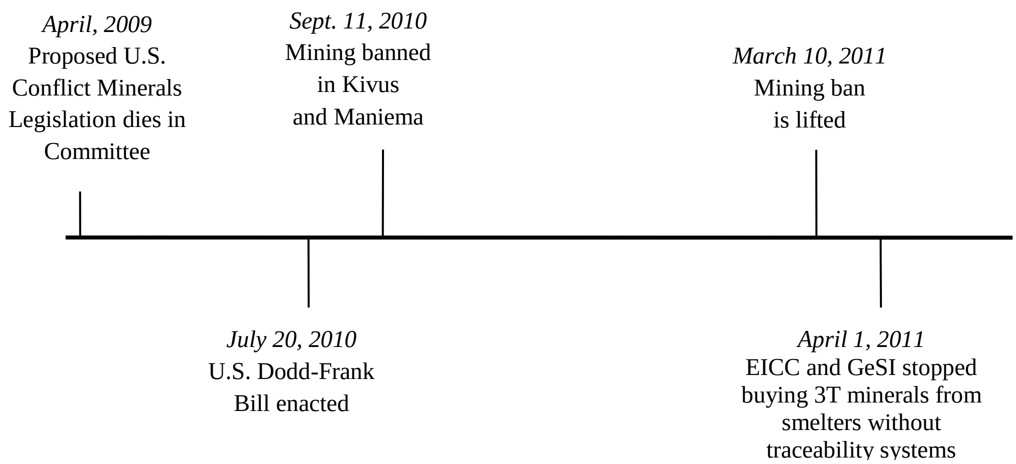


Figure 4: Available Data on Official Exports

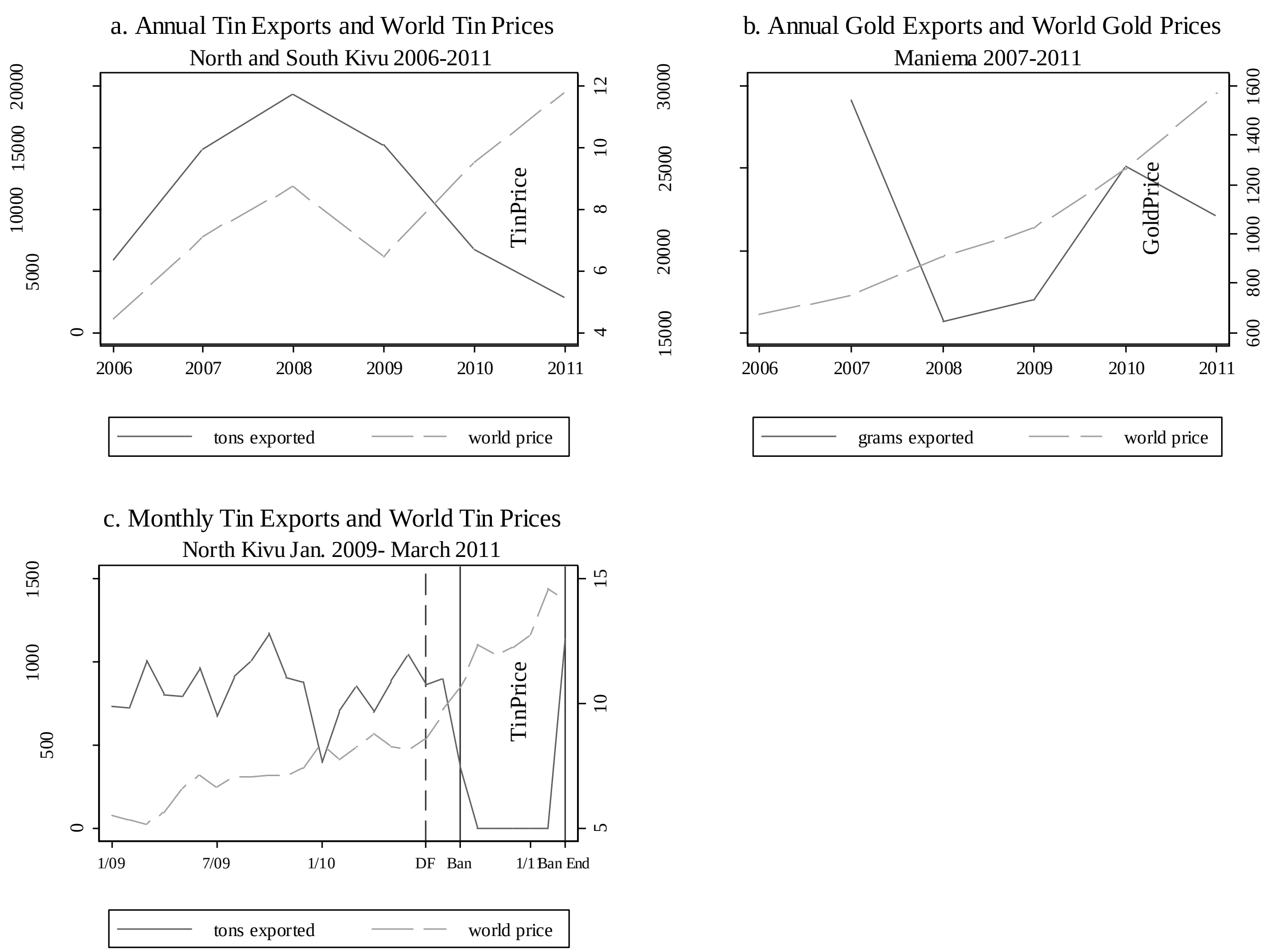


Figure 5
Decision Tree for Group 1 with a One-Period Planning Horizon

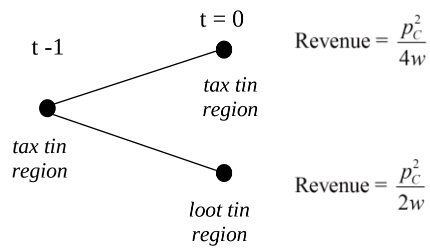


Figure 6
Decision Tree and Payouts for Group 1 for a Two Period Planning Horizon

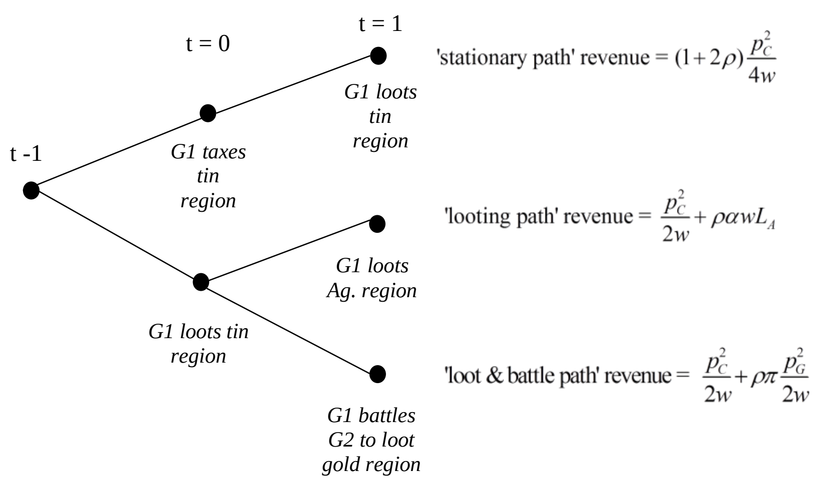


Figure 7: ACLED Violent Conflicts in the Eastern DRC

By Month (2004-2012)

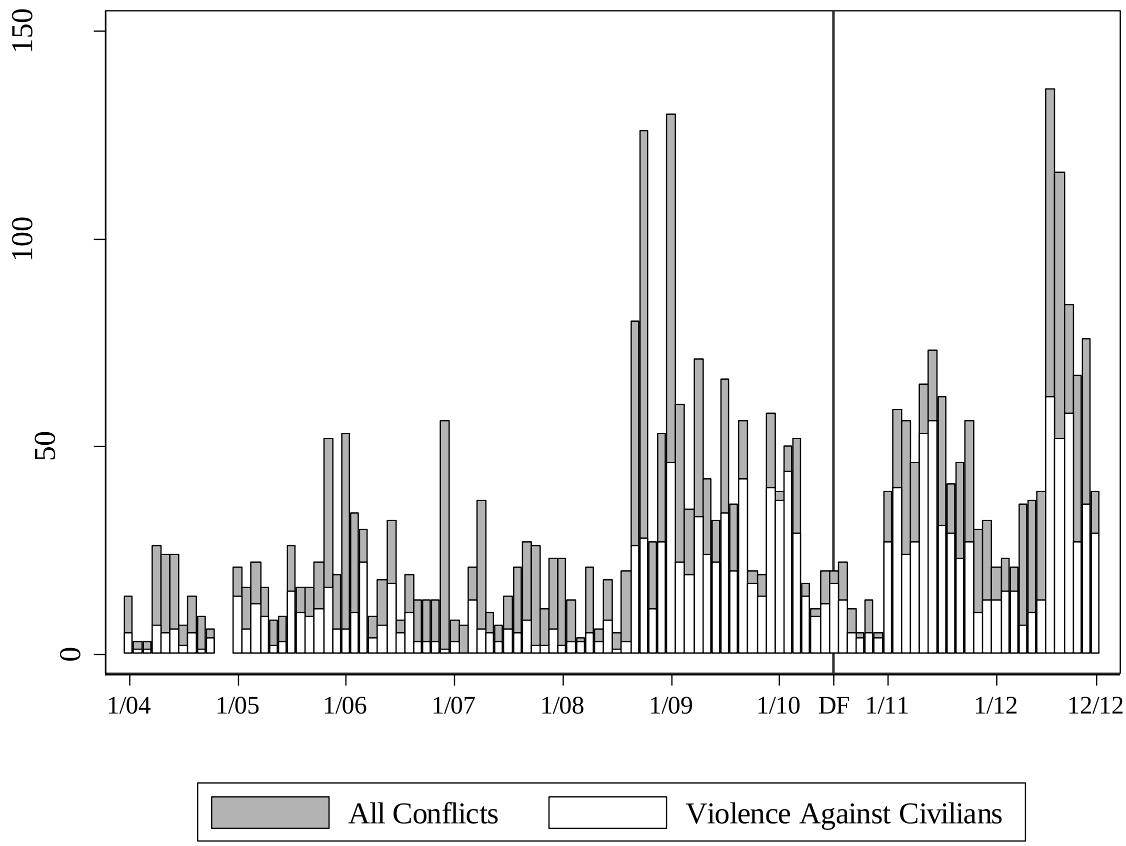
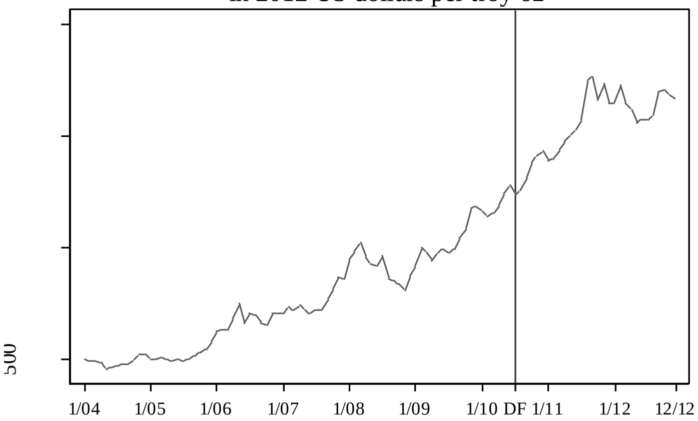
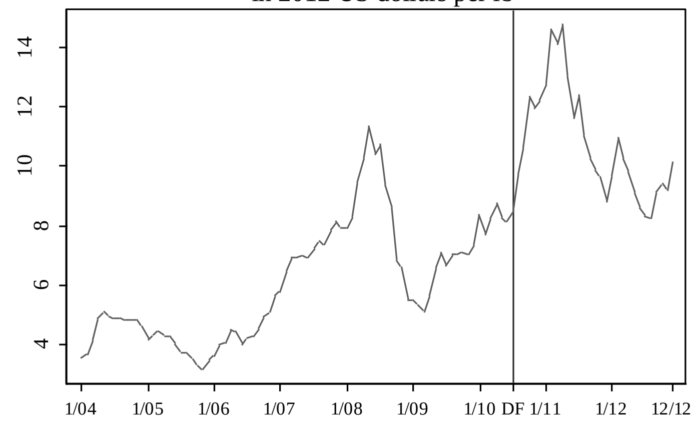


Figure 8: Monthly World Prices of Conflict Minerals
(2004-2012)

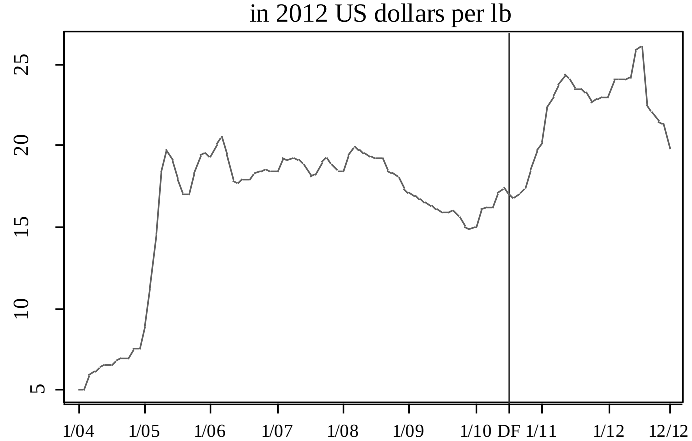
a. Gold
in 2012 US dollars per troy oz



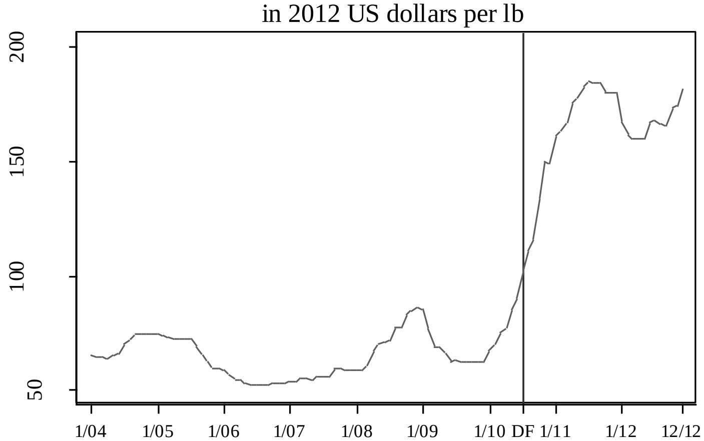
b. Tin
in 2012 US dollars per lb



c. Tungsten
in 2012 US dollars per lb

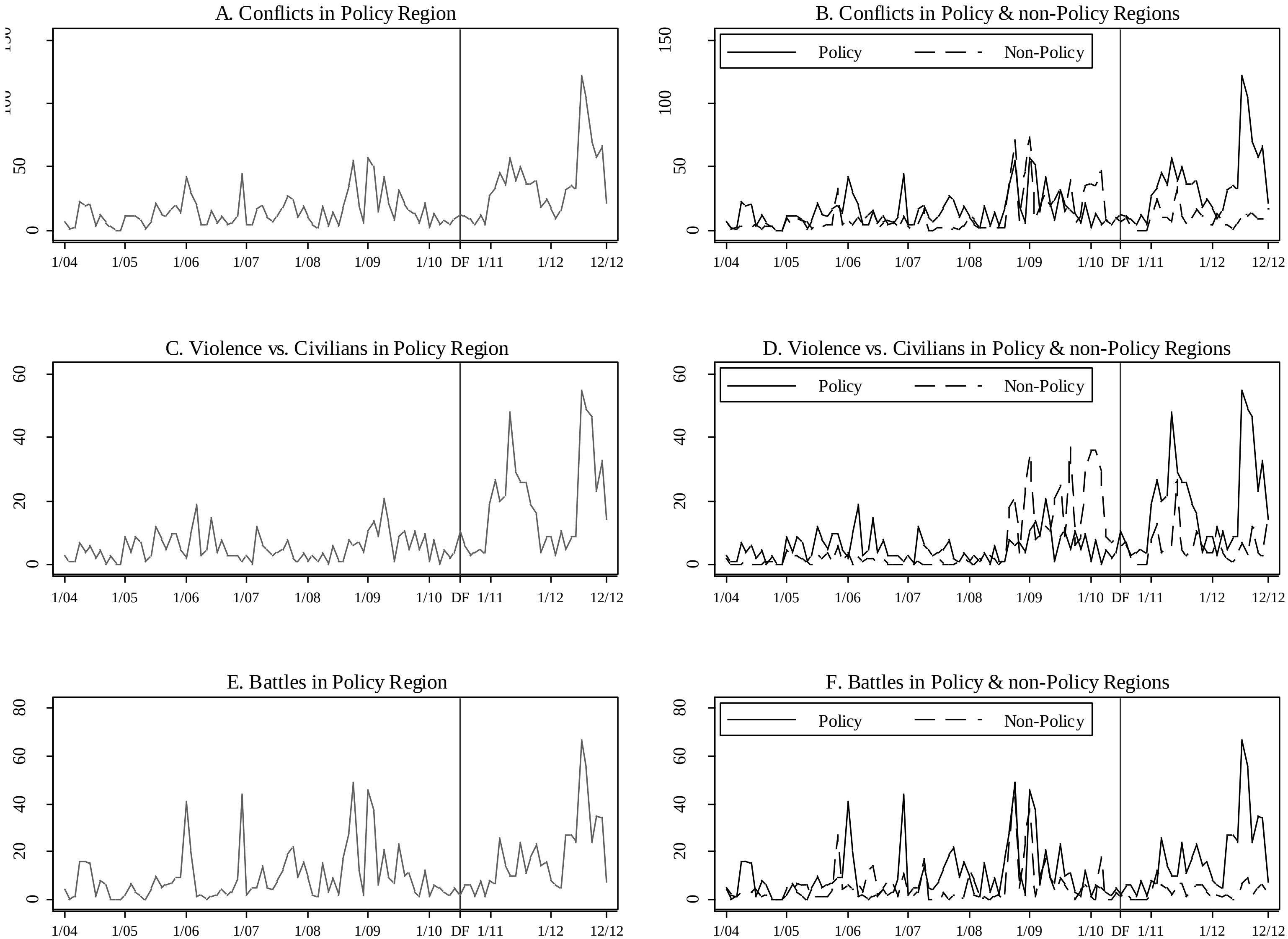


d. Tantalum
in 2012 US dollars per lb



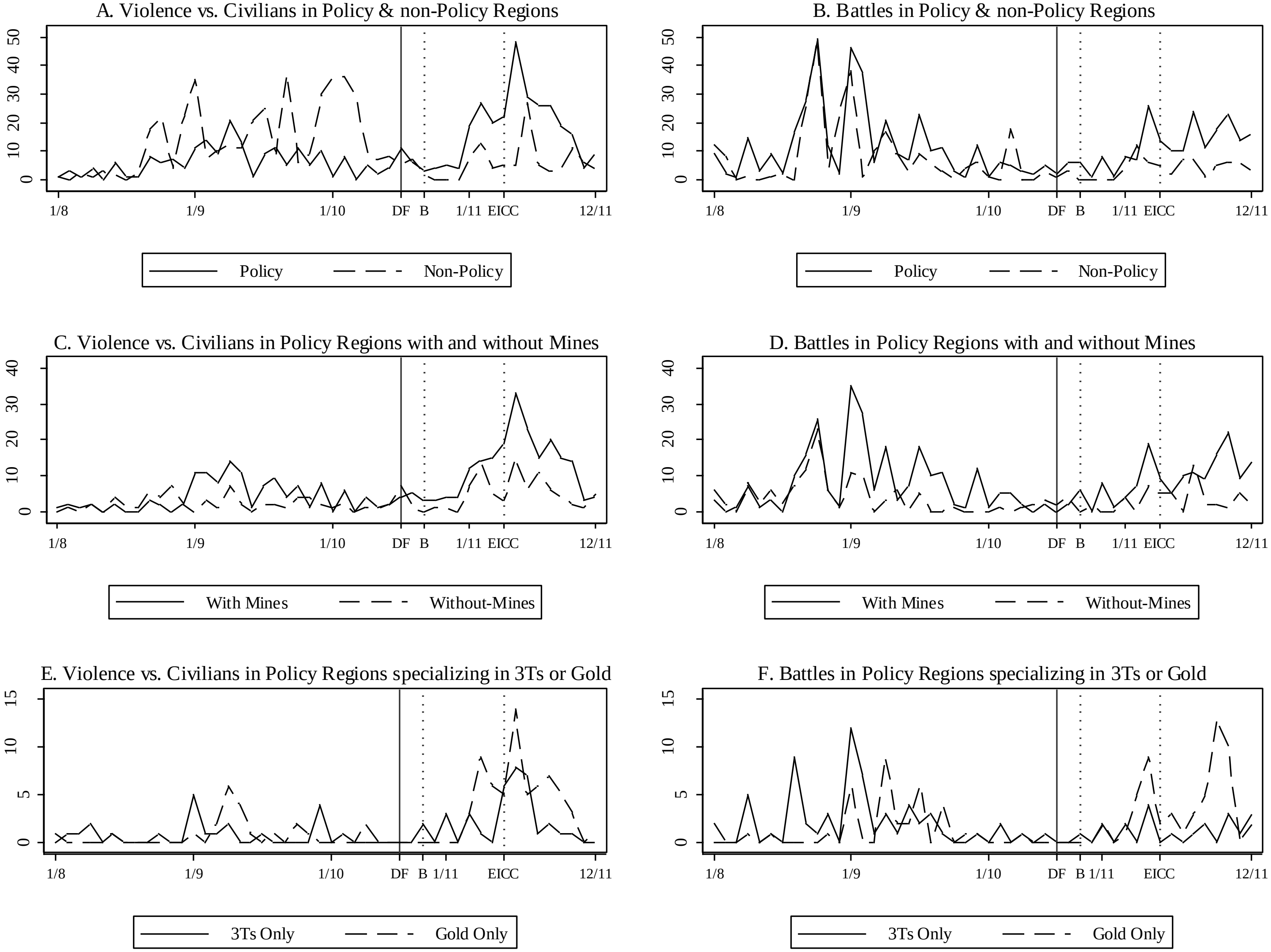
Notes: The source is the MetalPrices.com online subscription. The gold price represents the monthly average of the PM spot prices on London Market Exchange. The tin price is the monthly average of the cash official price paid by buyers on the London Market Exchange. The tungsten price represents the monthly average of the ferro tungsten alloy price. The tantalum price represents the monthly average price paid for tantalum scrap by U.S. Vacuum Processors.

Figure 9: Monthly Violent Conflicts in the Eastern DRC, 2004-2012



Notes: The source is the ACLED database (see Raleigh et al. 2010). The policy regions are defined in section 4.

Figure 10: Monthly Violent Conflicts in the Eastern DRC, 2008-2011



Notes: The source is the ACLED database (see Raleigh et al. 2010). The policy regions are defined in section 4.

Table 1: Mining Sites in Eastern DRC Prior to Conflict Mineral Policies

(by primary mineral)

Panel A: Mining Sites and 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 the entire Orientale province, but with less detail than the Orientale Hinterlands map. For example, the Orientale map does not estimate the number of workers at mines. The maps are described in detail by 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 Spittaels (2010). The MiMiKi maps are based on data collected during May-July 2009. The Hinterlands maps are based on data collected during June-July 2010. FARDC is the acronym for 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. FDLR is the acronym for the Democratic Forces for the Liberation of Rwanda. Mayi Mayi is an umbrella term for loosely affiliated groups of local militias. PNC is the acronym for the National Congolese Police. FRF is the acronym for the Forces Républicaines Fédéralistes.

Table 3: Summary Statistics
(2008-2011)

Variable	*Mean*	*Std. Dev.*	*Min*	*Max*	*Description*
Time Variant					
Conflicts[a]	0.563	2.424	0	57	# of violent conflict events
Civilians[a]	0.299	1.400	0	28	# of violence against civilians events
Battles[a]	0.263	1.455	0	36	# of battles between armed groups
Adj. conflicts[a]	3.425	8.544	0	131	# of violent conflict events in adjacent territories
Conf. indicator[a]	0.151	0.359	0	1	=1 if there is at least one violent conflict, otherwise =0
Civilians indicator[a]	0.111	0.314	0	1	=1 if there is at least one violence against civilian event, otherwise =0
Battle indicator[a]	0.093	0.290	0	1	=1 if there is at least one battle, otherwise =0
Policy indicator[b]	0.139	0.344	0	1	=1 starting in July 2010, for Section 1502 and mining ban territories, =0 otherwise
Gold price[c]	2.367	0.537	1.60	3.49	World price of gold, normalized at 1 based on the January 2004 price
Tin price[c]	2.561	0.701	1.43	4.12	World price of tin, normalized at 1 based on the January 2004 price
Tantalum price[c]	1.605	0.713	0.90	2.83	World price of tantalum, normalized at 1 based on the January 2004 price
Tungsten price[c]	3.690	0.554	2.93	4.80	World price of tungsten, normalized at 1 based on the January 2004 price
Rainfall anomalies[d]	0.063	1.105	-2.66	3.59	Difference in rainfall and 1951-2012 average for month, divided by st. deviation
Time Invariant					
Gold mines[e]	5.157	10.913	0	68	# of gold mining sites or deposits
Cassiterite mines[e]	2.829	6.529	0	33	# of cassiterite mining sites or deposits
Coltan mines[e]	0.300	1.211	0	9	# of coltan (tantalum) mining sites or deposits
Wolframite mines[e]	0.114	0.622	0	5	# of wolframite (tungsten) mining sites or deposits
Gold indicator[e]	0.486	0.500	0	1	= 1 if a territory has at least one gold mining site, otherwise =0
Cassiterite indicator[e]	0.257	0.437	0	1	= 1 if a territory has at least one cassiterite mining site, otherwise =0
Coltan indicator[e]	0.114	0.318	0	1	= 1 if a territory has at least one coltan mining site, otherwise =0
Wolf. Indicator[e]	0.057	0.232	0	1	= 1 if a territory has at least one wolframite mining site, otherwise =0

Notes: N=3360 for all variables, with 4 years, 12 months and 70 territories of observations. a) The source is the ACLED database. b) Takes a fractional value of 1/3 for July, 2010 because Dodd Frank was passed on July 21. For purposes here, 'Section 1502 territories' refers to territories on the U.S. State Department's map, which has been declassified and is available at: https://hiu.state.gov/Products/DRC_MineralExploitation_2011June14_HIU_U357.pdf . The mining ban territories are Maniema, North Kivu, and South Kivu. c) The source is MetalPrices.com. d) The source is GPCC at http://kunden.dwd.de/GPCC/Visualizer , e) The source is the IPIS maps available at www.ipisresearch.be/?&lang=en.

Table 4: Fixed Effects Estimates of Monthly Conflicts

in territories of Five Eastern Provinces (2008-2011)

	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Policy indicator	0.688**	0.580***	0.108	0.745**	0.587***	0.158	0.436**	0.424***	0.011	0.423**	0.420***	0.003
	(0.024)	(0.001)	(0.518)	(0.017)	(0.001)	(0.385)	(0.013)	(0.000)	(0.934)	(0.022)	(0.000)	(0.983)
Gold price *x* gold indicator				-0.244	-0.143	-0.101	-0.199	-0.126	-0.073	-0.197	-0.125	-0.072
Tin price *x* cassiterite indicator				-0.071	0.039	-0.110	-0.063	0.041	-0.104	-0.064	0.039	-0.103
Tant. price *x* coltan indicator				0.059	0.043	0.016	0.090	0.063	0.027	0.089	0.061	0.028
Tung. price *x* wolf. indicator				-0.578*	-0.358***	-0.220	-0.325**	-0.239***	-0.086	-0.330**	-0.243***	-0.087
Rainfall anomalies				0.142*	0.059	0.083**	0.094	0.036	0.058**	0.101	0.041	0.060*
Rainfall anomalies^2				-0.054**	-0.032*	-0.022	-0.037*	-0.024	-0.012	-0.039*	-0.026	-0.013
1 month lagged conflict							0.235***	0.092***	0.143***	0.235***	0.092***	0.143***
2 month lagged conflict							0.035	0.033***	0.002	0.034	0.032**	0.002
3 month lagged conflict							0.095**	0.036*	0.059**	0.096**	0.037*	0.059**
4 month lagged conflict							0.120***	0.070*	0.050***	0.120***	0.070*	0.050***
5 month lagged conflict							-0.088	-0.028	-0.060	-0.088	-0.028	-0.060
1 month lagged adj. terr conflict							0.007	0.007	0.000	0.007	0.007	0.000
2 month lagged adj. terr conflict							0.003	0.003	0.000	0.002	0.003	0.000
1 month pre-policy placebo										0.062	0.125	-0.063
2 month pre-policy placebo										0.125	0.181	-0.055
3 month pre-policy placebo										0.522	0.354	0.168
4 month pre-policy placebo										-0.811	-0.450	-0.360
5 month pre-policy placebo										-0.250	-0.333	0.082
Territory fixed effects (i=70)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time period effects (t=180)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (within)	0.040	0.039	0.041	0.046	0.043	0.045	0.143	0.106	0.118	0.144	0.107	0.119
Observations	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360

Notes: * p<0.10; ** p<0.05; *** p<0.01. Standard errors are clustered at the territory level. *P* values are shown in parentheses.

Table 5: Fixed Effects Estimates of Monthly Conflicts

For Subsamples of Territories and Mining Counterfactuals (2008-2011)

	Full Sample of Territories in Eastern DRC				*Sample Omits Territories with both 3T & Gold Mines*	
	Civilians	Battles	Civilians	Battles	Civilians	Battles
	(1)	(2)	(3)	(4)	(5)	(6)
Policy indicator	0.326^{**}	-0.223	0.396^{***}	-0.171	0.371^{***}	-0.262
	(0.018)	(0.255)	(0.004)	(0.334)	(0.006)	(0.169)
Policy indicator x mine indicator	0.179	0.426^{*}				
	(0.361)	(0.059)				
Policy indicator x 3T mine indicator			-0.214	-0.098	-0.284	-0.105
			(0.226)	(0.638)	(0.179)	(0.622)
Policy indicator x gold mine indicator			0.264	0.517^{**}	0.176	0.623^{**}
			(0.183)	(0.028)	(0.509)	(0.023)
Gold price *x* gold indicator	-0.158^{*}	-0.149	-0.177^{*}	-0.207	-0.184^{*}	-0.205
Tin price *x* cassiterite indicator	0.014	-0.167^{*}	0.066	-0.118	0.046	-0.006
Tant. price *x* coltan indicator	0.039	-0.031	0.071	-0.026	0.214	0.019
Tung. price *x* wolf. indicator	-0.256^{***}	-0.126	-0.225^{***}	-0.102	-0.156	-0.093
Rainfall anomalies	0.035	0.057^{**}	0.036	0.056^{**}	0.027	0.059^{**}
Rainfall anomalies^2	-0.024	-0.012	-0.025	-0.013	-0.021	-0.020
1 month lagged conflict	0.092^{***}	0.142^{***}	0.092^{***}	0.142^{***}	0.093^{***}	0.131^{***}
2 month lagged conflict	0.033^{***}	0.002	0.032^{**}	0.002	0.036^{**}	0.005
3 month lagged conflict	0.036^{*}	0.059^{**}	0.036^{*}	0.058^{**}	0.041^{*}	0.068^{***}
4 month lagged conflict	0.070^{*}	0.050^{***}	0.069^{*}	0.049^{***}	0.072^{*}	0.041^{***}
5 month lagged conflict	-0.028	-0.060	-0.028	-0.060	-0.041^{**}	-0.075
1 month lagged adj. terr conflict	0.007	0.000	0.007	-0.001	0.006	-0.003
2 month lagged adj. terr conflict	0.003	0.000	0.002	-0.001	0.002	0.000
Territory fixed effects (i=70)	Yes	Yes	Yes	Yes	Yes	Yes
Time period effects (t=180)	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (within)	0.106	0.119	0.106	0.120	0.102	0.119
Observations	3360	3360	3360	3360	2976	2976

Notes: * p<0.10; ** p<0.05; *** p<0.01. Standard errors are clustered at the territory level. *P* values are shown in parentheses.

Appendix: Constructing the Territory Level Rainfall Anomaly Variables

We estimated monthly precipitation amounts for the 150 territories of the DRC using following process. First, we downloaded precipitation normals from GPCC Visualizer (http://kunden.dwd.de/GPCC/Visualizer) as ascii ArcView GRID files, and then converted to rasters using the ArcGis ascii to raster tool. Next we downloaded error corrected monthly precipitation data as a NetCDF file. This file contained monthly precipitation data from 1901-2010 and had to be unpackaged to obtain the years relevant for our empirical analysis. The process to unpackage the file and convert individual months to ArcGis raster files was done with the help of a code written in Python. We next used the zonal statistics tool in ArcGis 10.2 to calculate average precipitation values for each of the 150 territories. We resampled the precipitation data to 0.1 degree resolution for this purpose, because in some cases the 1 degree pixels of precipitation data were larger than the territories. After resampling, we were able to calculate average precipitation values for all territories.

The precipitation data for 2004-2010 was already error corrected in GPCC raw data files, but we needed to correct the 2011 and 2012 data for systematic gauge errors prior to use, so that it would correspond to the 2004-2010 data. We executed the correction using the GPCC 1 degree relative systematic gauge error product, available for every month during 2011-2012 period from GPCC Visualizer. We converted the percent error to a multiplication factor which we applied to each month of the 2011-2012 precipitation grids. After this correction was achieved, we resampled the data to 0.1 degrees using the same procedure described above.

Table A1: Summary Statistics of Monthly Conflict by Territory
(2008-2011)

	Conflicts		***Civilians***		***Battles***	
	Mean	*Max*	*Mean*	*Max*	*Mean*	*Max*
Katanga Province						
Bukama	0.063	1	0.000	0	0.063	1
Dilolo	0.000	0	0.000	0	0.000	0
Kabalo	0.000	0	0.000	0	0.000	0
Kabongo	0.021	1	0.000	0	0.021	1
Kalemie	0.125	2	0.021	1	0.104	2
Kambove	0.021	1	0.021	1	0.000	0
Kamina	0.104	2	0.042	2	0.063	2
Kaniama	0.000	0	0.000	0	0.000	0
Kapanga	0.021	1	0.000	0	0.021	1
Kasenga	0.000	0	0.000	0	0.000	0
Kipushi	0.042	2	0.021	1	0.021	1
Kongolo	0.021	1	0.000	0	0.021	1
Lubudi	0.000	0	0.000	0	0.000	0
Lubumbashi	0.271	5	0.083	3	0.188	3
Malemba-Nkulu	0.000	0	0.000	0	0.000	0
Manono	0.000	0	0.000	0	0.000	0
Mitwaba	0.063	3	0.021	1	0.042	2
Moba	0.021	1	0.021	1	0.000	0
Mutshatasha	0.000	0	0.000	0	0.000	0
Nyunzu	0.042	2	0.000	0	0.042	2
Pweto	0.021	1	0.021	1	0.000	0
Sakania	0.021	1	0.000	0	0.021	1
Sandoa	0.000	0	0.000	0	0.000	0
Maniema Province						
Kabambare	0.417	4	0.250	3	0.167	3
Kasongo	0.000	0	0.000	0	0.000	0
Kibombo	0.021	1	0.021	1	0.000	0
Kindu	0.021	1	0.021	1	0.000	0
Lubutu	0.021	1	0.000	0	0.021	1
Pangi	0.063	2	0.000	0	0.063	2
Punia	0.146	3	0.063	1	0.083	2
North Kivu Province						
Beni	1.479	9	0.854	9	0.625	8
Goma	0.229	3	0.104	2	0.125	2
Lubero	1.771	14	0.958	11	0.813	6
Masisi	2.083	17	0.708	5	1.375	12
Rutshuru	3.729	24	1.396	8	2.333	22

Table A1: Summary Statistics of Monthly Conflicts by Territory
(Continued)

	Conflicts		*Civilians*		*Battles*	
	Mean	*Max*	*Mean*	*Max*	*Mean*	*Max*
Orientale Province						
Aketi	0.000	0	0.000	0	0.000	0
Ango	1.208	14	1.125	13	0.083	2
Aru	0.083	1	0.063	1	0.021	1
Bafwasende	0.229	5	0.000	0	0.229	5
Bambesa	0.021	1	0.021	1	0.000	0
Banalia	0.000	0	0.000	0	0.000	0
Basoko	0.000	0	0.000	0	0.000	0
Bondo	0.042	1	0.021	1	0.021	1
Buta	0.000	0	0.000	0	0.000	0
Djugu	1.771	31	0.667	13	1.104	18
Dungu	7.750	57	4.688	28	3.063	36
Faradje	0.896	9	0.625	6	0.271	3
Irumu	2.042	11	0.958	10	1.083	11
Isangi	0.104	1	0.083	1	0.021	1
Kisangani	0.063	1	0.063	1	0.000	0
Mahagi	0.083	2	0.063	1	0.021	1
Mambasa	0.167	3	0.063	1	0.104	2
Niangara	1.271	26	1.188	26	0.083	2
Opala	0.000	0	0.000	0	0.000	0
Polo	0.854	17	0.667	17	0.188	3
Rungu	0.438	4	0.250	3	0.188	3
Ubundu	0.083	2	0.042	1	0.042	1
Wamba	0.063	2	0.063	2	0.000	0
Watsa	0.229	6	0.146	6	0.083	2
Yohuma	0.000	0	0.000	0	0.000	0
South Kivu Province						
Bukavu	0.896	8	1	7	0.375	7
Fizi	1.792	12	1	6	1.021	9
Idjwi	0.000	0	0	0	0.000	0
Kabare	0.313	3	0	3	0.104	2
Kalehe	1.646	20	0	5	1.188	20
Mwenga	1.125	6	1	6	0.458	4
Shabunda	1.458	13	1	8	0.458	5
Uvira	0.750	6	0	6	0.292	4
Walungu	0.125	2	0	1	0.083	1
All 70 Territories	0.562	57	0.299	28	0.263	36

Table A2: Fixed Effects Estimates of Monthly Conflicts

in territories of Five Eastern Provinces (2004-2012)

	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Policy indicator	0.870***	0.504***	0.366***	0.843***	0.501***	0.342***	0.401***	0.253**	0.149**	0.395***	0.245**	0.151**
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.004)	(0.005)	(0.014)	(0.023)	(0.005)	(0.018)	(0.029)
Gold price *x* gold indicator				0.100	0.078	0.022	0.046	0.046	0.000	0.047	0.047	0.000
Tin price *x* cassiterite indicator				-0.098	-0.068	-0.031	-0.060	-0.046	-0.014	-0.059	-0.044	-0.015
Tant. price *x* coltan indicator				0.188	0.117	0.071	0.124	0.085	0.039	0.123	0.085	0.039
Tung. price *x* wolf. indicator				-0.023	-0.061	0.038	-0.026	-0.068**	0.042	-0.027	-0.069**	0.042
Rainfall anomalies				0.067	0.024	0.043**	0.043	0.012	0.031*	0.046	0.013	0.033*
Rainfall anomalies^2				-0.042**	-0.023*	-0.020**	-0.034**	-0.019*	-0.015*	-0.036**	-0.020*	-0.016*
1 month lagged conflict								0.263***	0.120***	0.143***	0.263***	0.119***
2 month lagged conflict								0.079***	0.051**	0.028	0.079***	0.051**
3 month lagged conflict								0.109***	0.041*	0.068***	0.109***	0.041*
4 month lagged conflict								0.076	0.054	0.021	0.076	0.054
5 month lagged conflict								-0.049	-0.007	-0.041	-0.049	-0.007
1 month lagged adj. terr conflict								0.017	0.012	0.004	0.017	0.012
2 month lagged adj. terr conflict								0.000	0.002	-0.002	0.000	0.002
1 month pre-policy placebo										0.028	0.025	0.002
2 month pre-policy placebo										0.045	0.054	-0.010
3 month pre-policy placebo										0.525	0.282	0.243
4 month pre-policy placebo										-0.824	-0.536	-0.287
5 month pre-policy placebo										-0.175	-0.379	0.204
Territory fixed effects (i=70)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time period effects (t=180)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (within)	0.050	0.048	0.041	0.052	0.051	0.042	0.184	0.167	0.120	0.184	0.168	0.121
Observations	7560	7560	7560	7560	7560	7560	7560	7560	7560	7560	7560	7560

Notes: * p<0.10; ** p<0.05; *** p<0.01. Standard errors are clustered at the territory level. *P* values are shown in parentheses.

Table A3: Fixed Effects Estimates of Monthly Conflict Indicator
in territories of Five Eastern Provinces (2008-2011)

	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Policy indicator	0.129***	0.136***	0.058*	0.131***	0.129***	0.072**	0.097**	0.099***	0.049*	0.093**	0.098***	0.051
	(0.001)	(0.000)	(0.071)	(0.005)	(0.001)	(0.047)	(0.012)	(0.002)	(0.096)	(0.022)	(0.003)	(0.109)
Gold price *x* gold indicator				-0.007	0.016	0.000	-0.006	0.019	0.002	-0.005	0.019	0.002
Tin price *x* cassiterite indicator				0.007	0.010	-0.028	0.007	0.010	-0.027	0.007	0.010	-0.028
Tant. price *x* coltan indicator				0.017	0.004	0.040	0.021	0.006	0.043	0.021	0.006	0.042
Tung. price *x* wolf. indicator				-0.071**	-0.028	-0.077*	-0.052**	-0.010	-0.062*	-0.053**	-0.010	-0.061*
Rainfall anomalies				0.001	0.008	-0.007	-0.002	0.005	-0.009*	-0.002	0.006	-0.008*
Rainfall anomalies^2				-0.009**	-0.006	-0.004	-0.008**	-0.005	-0.003	-0.008**	-0.005	-0.004
1 month lagged conflict							0.015***	0.015***	0.011***	0.015***	0.015***	0.011***
2 month lagged conflict							0.008**	0.009***	0.009**	0.008**	0.009**	0.009**
3 month lagged conflict							0.005*	0.004*	0.001	0.005*	0.004*	0.001
4 month lagged conflict							0.002	0.001	0.004	0.002	0.001	0.004
5 month lagged conflict							0.007*	0.003	0.003	0.007*	0.003	0.004
1 month lagged adj. terr conflict							0.002	0.001	0.001	0.002	0.002	0.001
2 month lagged adj. terr conflict							0.002	0.002	0.001	0.002	0.002	0.001
1 month pre-policy placebo										-0.012	0.011	0.014
2 month pre-policy placebo										-0.044	-0.028	-0.002
3 month pre-policy placebo										0.050	0.066	0.044
4 month pre-policy placebo										-0.111*	-0.083**	-0.071
5 month pre-policy placebo										0.009	0.018	0.078
Territory fixed effects (i=70)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time period effects (t=180)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (within)	0.069	0.065	0.046	0.072	0.067	0.052	0.107	0.102	0.077	0.108	0.102	0.078
Observations	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360

Notes: * p<0.10; ** p<0.05; *** p<0.01. Standard errors are clustered at the territory level. *P* values are shown in parentheses.

Table A4: Fixed Effects Estimates of Monthly Conflicts

in territories of Five Eastern Provinces (2008-2011)

	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles	Conflicts	Civilians	Battles
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Policy indicator	0.688**	0.580***	0.108	0.777**	0.611***	0.166	0.450**	0.436***	0.013	0.438**	0.433***	0.005
	(0.024)	(0.001)	(0.518)	(0.016)	(0.001)	(0.374)	(0.010)	(0.000)	(0.925)	(0.020)	(0.000)	(0.974)
Gold price *x* No. gold mines				-0.006	-0.003	-0.003	-0.004	-0.002	-0.002	-0.004	-0.002	-0.002
Tin price *x* No. cassiterite mines				-0.007	-0.003	-0.003	-0.006	-0.003	-0.003	-0.006	-0.003	-0.003
Tant. price *x* No. coltan mines				-0.037	0.006	-0.043**	0.002	0.029*	-0.027	0.002	0.028	-0.026
Tung. price *x* No. wolf. mines				-0.141*	-0.088**	-0.053	-0.083*	-0.059**	-0.024	-0.084*	-0.060**	-0.024
Rainfall anomalies				0.146*	0.062	0.084**	0.097	0.039	0.059**	0.104	0.044	0.060*
Rainfall anomalies^2				-0.054**	-0.032*	-0.022	-0.037*	-0.024	-0.013	-0.040*	-0.026	-0.013
1 month lagged conflict							0.236***	0.093***	0.143***	0.236***	0.093***	0.143***
2 month lagged conflict							0.035	0.033***	0.003	0.035	0.033**	0.002
3 month lagged conflict							0.095**	0.037*	0.059**	0.096**	0.037*	0.059**
4 month lagged conflict							0.120***	0.070*	0.050***	0.120***	0.070*	0.049***
5 month lagged conflict							-0.088	-0.028	-0.060	-0.088	-0.028	-0.060
1 month lagged adj. terr conflict							0.007	0.007	0.000	0.007	0.007	0.000
2 month lagged adj. terr conflict							0.002	0.003	0.000	0.002	0.003	-0.001
1 month pre-policy placebo										0.072	0.129	-0.057
2 month pre-policy placebo										0.136	0.188	-0.053
3 month pre-policy placebo										0.538	0.374	0.164
4 month pre-policy placebo										-0.800	-0.439	-0.361
5 month pre-policy placebo										-0.242	-0.327	0.085
Territory fixed effects (i=70)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time period effects (t=180)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (within)	0.040	0.039	0.041	0.044	0.042	0.044	0.142	0.105	0.118	0.143	0.107	0.118
Observations	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360

Notes: * p<0.10; ** p<0.05; *** p<0.01. Standard errors are clustered at the territory level. *P* values are shown in parentheses.