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Sexual Violence as a Weapon of War

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Sexual violence as a weapon of war *

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Abstract

This study highlights that armed groups may use sexual violence against civilians as a strategy to extort economic resources. We combine new and fine-grained data about local economic resources and sexual violence against civilians by armed groups in Africa from 1997 to 2018 at the 0.5×0.5 degree resolution. We show that an exogenous rise in the value of artisanal mining increases the incidence of sexual violence. We demonstrate how standard rationales of violence as a taxation strategy explain this finding. Theoretically, if the resource is labor-intensive, the armed group needs civilian labor to produce the resource. Sexual violence, a form of non-lethal violence that allows perpetrators to enforce high taxation while preserving local labor, will become more likely if (i) the price of the resource increases (rapacity effect), and (ii) the resource can be concealed easily (is difficult to tax). Our empirical findings align with our model: an increase of one standard deviation in the value of gold mined in artisanal mining areas – a labor-intensive resource that can easily be concealed – increases sexual violence by two thirds of the sample mean. In contrast, local resources that are either more capital-intensive than artisanal mining, or the production of which is harder to conceal than gold, have no relation to sexual violence. Moreover, we show that the relation between artisanal mining value and sexual violence is mostly driven by the presence of armed actors who are most likely to rely on illegal local taxation (rebel groups).

JEL codes: D74, J16, O13, Q34.
Keywords: conflict, sexual violence, artisanal mines, industrial mines, agriculture

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1 Introduction

> "In fact rape and sexual violence constitute a formidable weapon of war [...] It is obvious that the rapes are not motivated by sexual impulses but constitute a means of debilitating, if not annihilating, a population. In other words, the attackers can take over these places as absolute masters. These places are often mining areas rich in coltan or in gold. "

Denis Mukwege, Nobel laureate, UNESCO speech, 2018

The 2018 Nobel Peace Prize award to Dr Denis Mukwege and Nadia Murad underlines "their efforts to end the use of sexual violence as a weapon of war and armed conflict," drawing large-scale attention to an understudied issue with devastating impacts on the victims and their communities (Ba and Bhopal, 2017). According to the UN (2013), sexual violence in conflict settings affected more than 60,000 women in Sierra Leone (1991-2002), up to 250,000 in Rwanda (1994), more than 40,000 in Liberia (1983-2003), up to 60,000 in the former Yugoslavia (1992-1995), and more than 200,000 in the Democratic Republic of Congo (from 1998 and ongoing). While 12% of the world population lived in a conflict zone in 2016 (Bahgat et al., 2018), conflict zones do not systematically witness sexual violence (Wood, 2009). What are the local determinants that make a conflict zone at risk of sexual violence?

Qualitative evidence indicates that economic motives such as the presence of natural resources may play a crucial role in triggering sexual violence by armed groups.[1] The Nduma Defense of Congo (NDC) in the Democratic Republic of Congo (DRC) is a typical example. This group appeared in the international news when it participated in the rape of at least 387 civilians in 13 villages of the resource-rich Walikale territory between July 30 and August 2, 2010. After the attack, a local leader specifically mentioned the control of minerals as a reason for this act of violence by stating "The minerals are our curse" (Smith, 2010). In 2017, the NDC-Renouvele still levied illegal taxation through mining permits, mining output taxes, or a weekly agricultural tax in more than 100 villages (Sánchez De La Sierra, 2020).[2] The link between resource exploitation and sexual violence is an evolving area of concern globally: based on data from 18 countries, the UN (2019) concludes that "Non-state armed groups, using sexual violence to enforce control over illicit economic activities, including the exploitation of natural resources, were responsible for most cases."

This study highlights the impact of local economic resources on the perpetration of sexual violence by armed groups. We consider sexual violence to be any action that inflicts harm of a

[1] Bleasdale (2009) is one of the first to document a direct link between the two, based on interviews of armed group leaders in the Democratic Republic of Congo.

[2] About 56% of the artisanal mines in the 2016 IPIS survey for eastern DRC operate under the control of an armed group and illegal taxation takes place at 75% of these mines (Weyns et al., 2016). Women who live close to one of these mines are more likely to have experienced sexual violence (Rustad et al., 2016).

sexual nature in a conflict setting (as in the ACLED, 2019). Inspired by qualitative evidence, we offer two main contributions. First, we develop a theoretical framework where sexual violence is a form of non-lethal violence that armed groups may use to enforce taxation on civilians. Our main prediction is that the perpetration of sexual violence increases with the price of a labor-intensive and concealable resource. Second, we document empirically how sexual violence reacts to exogenous variations in the global prices of three different local resources spread across the African continent. Aligned with our model's main prediction, we document that an increase in the international gold price increases sexual violence in areas prone to artisanal gold mining – a resource that is labor-intensive and easily concealable.

Our theoretical framework is a simple model of violence against civilians as a way to enforce taxation. We start from the observation that sexual violence is usually a non-lethal form of violence that armed groups may use against civilians. The main building blocks of the models are threefold: (i) Armed groups depend on local civilian production for critical resources (Humphreys and Weinstein, 2006). (ii) Civilians can conceal the resources they produce from taxation (Sánchez De La Sierra, 2020). (iii) The armed group can either stay non-violent (low taxation power), exert non-lethal violence (to terrorize civilians and impose a higher tax), or kill civilians (to extract the resource directly). The model's predictions highlight the impact of the characteristics of the local resource on the incentives for armed groups to resort to violence against civilians. First, if the resource is labor-intensive, there are incentives for preserving local labor and avoiding lethal violence. Around these labor-intensive resources, non-lethal violence is more likely to occur if (i) the price of the resource increases, because a high price increases the incentives to impose higher taxes (predatory effect), and (ii) the resource can be concealed easily, because it is then more difficult to monitor taxation. In areas where the resource is capital-intensive, lethal violence is more likely to take place, as the need for local labor is reduced. Our model therefore yields key predictions for the analysis of the local triggers of sexual violence, and allows this analysis to be embedded in a broader typology of violence.

Our empirical analysis documents how the perpetration of sexual violence reacts to the value of various taxable local resources. We assemble data covering all African countries, divided in cells of size 0.5×0.5 degrees latitude and longitude (55km $\times$ 55km at the equator), over the period 1997 to 2018. Sexual violence data is notoriously difficult to gather. However, the latest version of the Armed Conflict Location and Event dataset dedicates a special section to the separate coding of sexual violence in conflict settings (ACLED, 2019).[3]. For each cell, we know the yearly incidence of both sexual violence and other forms of violence against

[3]Empirical studies of sexual violence are typically concerned about underreporting, as rape is associated with strong social stigma. It is crucial to note that the type of violence that we study has little in common with intimate partner violence or rapes that are typically reported to the police. The ACLED database documents larger-scale events of sexual violence that are perpetrated by armed groups to terrorize local populations. The armed groups have no reason to hide these events; sometimes they even have an interest in making them publicly known (Chu and Braithwaite, 2018). We nonetheless acknowledge the risk of the measure being noisy. Our empirical approach ensures that our results do not come from an increase in the social acceptability of reporting sexual violence, or from an increase in media attention toward sexual violence over time (discussion in Section 6)

civilians. We cross this information with measures of artisanal gold mining (a labor-intensive and easily concealable resource),[4] industrial mining (a capital-intensive and easily concealable resource), and agriculture (a labor-intensive resource of which the output is more difficult to conceal than that of mining).

To establish a causal relationship, we investigate exogenous variations in the world price of the local resources present in each cell.[5] Our empirical specification accounts for time-invariant local characteristics such as a cell initial resource endowments (in particular the presence of minerals or agricultural suitability), the topology, or the distance to markets (main cities and ports). Following our theoretical framework, we also partial out any time variation at the ethnic homeland and country level to account for the bilateral relation that might exist between the local civilian population and the armed groups present in a specific ethnic area that year. By doing so, we account for example for the salience of ethnic hatred between the groups in an ethnic homeland (a suspected amplifier of sexual violence), the political standing of a specific ethnic group (which might impact the strength of the local rule of law, or ethnic favoritism and patronage), or the wages of fighters in each area (accounting for the opportunity cost argument). For each area, our results rest on the within-resource panel variation coming from the plausibly exogenous changes in the world price of that resource, accounting for a rich set of time-varying, ethnic group-specific, unobserved heterogeneity.

We document that a rise in the value of gold increases the perpetration of sexual violence against civilians in cells prone to hosting artisanal gold mines. A one standard deviation increase in the price of gold is associated with a 0.002 increase in the incidence of sexual violence, which represents roughly two thirds of the average incidence of sexual violence in the sample. The value of artisanally mined gold – a labor-intensive and easily concealable resource – is therefore an important determinant of sexual violence. This result is robust to a battery of robustness checks.

To ensure that our baseline specification captures fundamental features of the relation between local resources and sexual violence, we build on our theoretical framework and analyze the determinants of the other technologies of violence that armed groups may use against civilians. One may be concerned that our baseline results on sexual violence come solely from a bias in media coverage or social acceptability in reporting this form of violence. To assess the relevance of this concern, we show that we obtain the same results for sexual violence and for other forms of non-lethal violence that do not share the symbolic load of sexual violence. Artisanal mining value apears to increase non-lethal violence against civilians, even when we exclude sexual violence events from the sample of non-lethal events. In contrast, we also show

[4]Artisanal mining is a labor-intensive activity that relies on primordially local labor and limited local tools. Taking the example of gold, artisanal mines employ 90% of the gold mining sector workforce, but produce only 20% of the total gold available on international markets (the remaing 80% of the gold production comes from industrial mines IGF, 2017).

[5]Similarly to Dube and Vargas (2013), Berman et al. (2017), or Sánchez De La Sierra (2020), we investigate the world price variations as a source of exogenous shock, given that all cells in our sample are small enough to be pricetakers on international commodity markets.

that an increase in the value of (capital-intensive) industrial mining only increases the use of lethal violence. The value of agriculture, where production is harder to hide, shows no systemic association with either form of violence. The different relations between resource prices and each form of violence are further evidence aligned with our theoretical predictions and consistent with armed groups strategically choosing which technology of violence they resort to.

As the existing literature on sexual violence focuses on actor-specific drivers, we also consider the potential characteristics of perpetrators and civilians that might impact our results.[6] We show that the relation between artisanal mines' value and sexual violence is magnified in the presence of rebel groups – the actors most likely rely on local economic resources to finance their activities. We can also document that subsistence activities linked to more equal gender norms among the local civilian population magnify our baseline results. Aligned with our theoretical framework, we point out that our results are magnified in countries with strong levels of ethnolinguistic fragmentation as well as in states with institutional difficulties (low levels of the rule of law or government performance).

We contribute to three main literature streams: (i) the understanding of sexual violence during conflicts, (ii) conflict and natural resources and (iii) the local impact of artisanal mining.

We first contribute to the literature on the determinants of sexual violence during conflicts by showing that the incidence of sexual violence reacts to local economic incentives. Sexual violence is not a systemic byproduct of war: combatants engaged in sexual violence in approximately half of the civil conflicts between 1989 and 2008 (Chu and Braithwaite, 2018; Wood, 2009). To understand the sources of these variations in the perpetration of sexual violence, a growing literature focuses on actor characteristics. The key characteristics considered to date broadly relate to gender norms, the internal dynamics of armed groups, or the ethnic dimension of the conflict. First, unequal gender norms appear to increase sexual violence through highly militarized masculinity (Wood, 2006), patriarchal culture (Wood, 2014), or divergences in ancestral gender norms between the armed groups and the local civilian population, as measured by historical ethnic homeland characteristics (Guarnieri and Tur-Prats, 2020). The association between gender norms and sexual violence is however not systemic: none of the measures of contemporary gender inequality considered by Cohen (2013) relate to the perpetration of sexual violence in Africa. Second, internal group characteristics may also matter. Sexual violence has for example been argued to either be the consequence of a lack of internal sanctions and norms in the armed group (Wood, 2006), or to be used as a key device for integration and bonding among armed group members Cohen (2013). Lastly, actors engaged in ethnic genocides may be more likely to perpetrate sexual violence, as it is a way to dehumanize the targeted group or alter its ethnic identity. This ethnic hatred has been put forward as a motivation behind the

[6] Our baseline results are independent from the incidence of any battle or any other sort of ACLED event in a cell year: these other violent events are not the mediator of the relation between the value of resources and sexual violence.

prevalence of sexual violence in Bosnia and Rwanda (Benard, 1994; Short, 2002; Weitsman, 2008), although at the scale of the African continent, ethnic conflicts do not appear to be more prone to sexual violence than other conflicts (Cohen, 2013). However, even actors who perpetrate sexual violence will not do so everywhere and always. Our contribution is to shift the focus to the characteristics of the places where and times when sexual violence happens. We argue that along with armed groups' characteristics, local economic incentives may be decisive in triggering sexual violence.

Our study also contributes to the literature that links local income shocks and conflicts. This string of research provides evidence of two opposite reactions of violence to natural resources: either a positive relation, a predatory effect, as the resource gets more valuable to grab; or a negative relation, an opportunity cost effect, as wages increase with the value of the resource, complicating the recruitment of fighters (Blair et al., 2021). In line with the predatory effect, diamonds – which are prone to artisanal mining – tend to increase civil conflicts or fatalities across Africa (Lujala et al., 2005; Rigterink, 2020), while Stoop et al. (2019) document an increase in conflicts around artisanal gold mines when the gold price increases in the eastern part of the DRC.[7] Similarly for industrial mines, we know that their exploitation – or an increase in their value – leads to civil conflicts, battles, and mass killing (Berman et al., 2017; Esteban et al., 2015a; Morelli and Rohner, 2015). Focusing on agricultural resources, civil conflicts as well as riots react to the world demand for agricultural commodities (Berman and Couttenier, 2015; McGuirk and Burke, 2020).[8] However, in Columbia, Dube and Vargas (2013) find contrasting effects of price variations on conflict that align with the theoretical predictions Dal Bó and Dal Bó (2011) developed: in the labor-intensive agricultural sector, conflict decreases with price, while in the capital-intensive oil sector, conflict increases with price. We contribute to this literature by focusing specifically on sexual violence against civilians.[9] To the best of our knowledge, this study is the first to simultaneously consider three resources (artisanal mines, industrial mines, and agriculture) that differ on two dimensions – labor intensity and concealability. This heterogeneity in resource characteristics is key to being able to explicitly model how sexual violence as a technology of violence relates to economic rationales.

Finally, we contribute to the recent literature on the impact of artisanal mining by doc-

[7]We also depart from the lootable diamond and conflict literature with our focus on concealability. Concealability, also used by Sánchez De La Sierra (2020), accounts for the interaction between armed groups and civilians, where the civilians have the option to hide a part of their production before armed groups tax it.

[8]Also to droughts (Couttenier and Soubeyran, 2014), water scarcity (Almer et al., 2017; Harari and Ferrara, 2018) or soil productivity (Berman et al., 2020b).

[9]The closest studies considering civilian targets are Humphreys and Weinstein (2006); Morelli and Rohner (2015). Our approach differs in its topic, time horizon, and geographic scale. Humphreys and Weinstein (2006) collected a cross-section of original data from Sierra Leone that allows them to show how internal dynamics to the armed groups relate to an aggregated index of civilian abuse. Our work differs by focusing on the local economic drivers of sexual violence, while accounting for local actors' characteristics, in data spanning the African continent over 21 years. Morelli and Rohner (2015) show how oil or diamond production in an ethnic homeland may increase the risk of massacres of members of that ethnic group. We differ in our scale of analysis (at the fine-grained cell level), the type of violence that we consider (lower intensity but more prevalent in time and space), and the modeling of heterogeneous effects for three resources.

umenting the relation to violence of a new continent-wide proxy for artisanal gold mining. Artisanal mining, which accounts for 20% of the global mineral production (Buxton, 2013), is a labor-intensive and often informal activity. Directly or indirectly, 1.5% to 4% of the world's population depend on artisanal mining for their livelihood (considering both miners and their families, WB, 2009). However, the development impact of these mines is still unclear, as researchers lack data about where and when they operate.[10] In this study, we exploit for the first time a new continent-wide map of areas that are prone to artisanal gold mining, which is by far the main employment provider in the artisanal sector of the African continent (Hilson, 2016). This map, built by Girard and Vic (2020), synthesizes recent advances in geological research. We are therefore able to establish a causal link between violence against citizens and artisanal mining. We show that the purported link between artisanal mining and sexual violence suggested in qualitative accounts is a robust systemic empirical feature in data covering the continent, and we distinguish this link from the relation between industrial mines and violence. We show that this link appears to be driven by armed group incentives to appropriate part of the local rent.

We believe that our findings have important policy implications. Our results highlight that the perpetration of sexual violence may be consistent with strategic decision-making by armed groups (using a tool of terror to enforce illegal taxation). Showing that sexual violence may result from strategic calculation implies that it may be (in part) avoidable. For example, our results draw attention to initiatives for the traceability of the mineral supply chain, such as those that the OECD aims to enforce through the Responsible Supply Chains of Minerals standards. Our results also highlight that NGOs and external observers may want to devote extra attention to regions with a high presence of artisanal mining when the value of a local mineral increases sharply.

The paper is organized as follows. In Section 2 we present the background on sexual violence. Section 3 introduces the theoretical framework. Sections 4 and 5 describe the data and the identification strategy respectively. Section 6 displays the results. Section 7 discusses the role of the actors and institutional context, and section 8 concludes.

[10]The WB (2015) report, which is supposed to summarize the state of knowledge on the development impact of gold mining, notes that *"An important caveat is that the focus of the study is on large-scale 'industrial' gold mining and not artisanal and small-scale gold mining that often takes place in proximity to large-scale mining. The data cannot be disaggregated to distinguish between these two classes of mining"*. To overcome this data challenge, recent literature resorts to various strategies: detailed data collection from regions in counties by means of surveys (Parker et al., 2016; Sánchez De La Sierra, 2020; Stoop et al., 2019), nationwide administrative data (Bazillier and Girard, 2020), machine learning over satellite images (Guenther, 2018; Romero and Saavedra, 2016), or a continent-wide sorting of diamond deposits (Lujala et al., 2005; Rigterink, 2020).

2 Background on sexual violence

Despite being reported as a historical phenomenon, the International Criminal Court only recognized wartime sexual violence as a war crime and a crime against humanity in 2002. In 2008, the United Nations Security Council argued that "women and girls are particularly targeted by the use of sexual violence, including as a tactic of war to humiliate, dominate, instil fear in, disperse and/or forcibly relocate civilian members of a community or ethnic group." This officialized the idea that sexual violence is used as a strategic weapon of war.

Sexual violence is fundamentally distinct from other forms of violence on two dimensions that are important for our study.

First, sexual violence is a specific form of violence in that it requires a conscious intention. Unlike other forms of lethal or non-lethal violence (such as wounding or killing civilians) which may be carried out either intentionally or unintentionally, conflict-related sexual violence is always carried out intentionally (Anderson, 2010; Krain, 2006; Nagel, 2019).

From the perpetrator's perspective, sexual violence has the clear advantage of tremendous symbolic consequences. Numerous qualitative accounts underpin that the symbolic weight associated with sexual violence goes beyond that of any other form of non-lethal violence, and potentially even lethal violence. According to Nagel (2019), "[s]exual violence establishes both the literal and symbolic domination and subordination of the other in disarming and feminizing both the direct victim and symbolically the community." Below, we refer to qualitative evidence, and elaborate on the topic in Appendix Section 8.2.

The example of Nduma Defense of Congo-Renouvele in the DRC demonstrates the intentional nature of the perpetration of sexual violence and its consequences in terms of dominating local civilians. The sexual assaults to which we referred in the introduction were perpetrated together with other forms of non-lethal violence: parallel to the 387 rapes, at least 923 houses and 42 shops in various villages were looted. However, sexual violence left a distinctive mark. The final UN report on the matter, the OHCHR (2011), cites a local victim of the Nianga ethnic group's testimony: "It is better to die than being raped by FDLR and their allies, because such rape is the worst humiliation against a human being." The report concludes that armed groups that perpetrated sexual violence on local civilians purposefully decided "to scare them forever through extremely humiliating acts, hence the planning of mass rapes."

Similarly, in Sierra Leone, Human Rights Watch notes that "[C]onflict-related sexual violence serves a military and political strategy. The humiliation, pain, and fear inflicted by the perpetrators serve to dominate and degrade not only the individual victim but also her community. Combatants who rape in war often explicitly link their acts of sexual violence to this broader social degradation. The armed conflict in Sierra Leone was no exception. The rebels sought to dominate women and their communities by deliberately undermining cultural values and community relationships, destroying the ties that hold society together." (HRW, 2003b).

More recently, in Sudan, the activist Dalia El Roubi, a member of the opposition Sudanese

Congress Party who worked with Darfuris displaced by the conflict, notes that "[t]he symbolism behind the rape of women is very substantial, it's aimed at breaking society. You rape 80 women, you rape the whole village" (Jacinto, 2019). A key informant interviewed by Devries et al. (2017) in Juba notes "[i]t's about dignity – if you rape another man's wife, it dehumanises the woman and the man."

It is noteworthy that several accounts link such physical and highly symbolic sexual aggression to natural resource exploitation. Beyond the abovementioned conflicts in the DRC, Sierra Leone, and Sudan, known to have roots in natural resource exploitation (Assal, 2006; Le Billon and Levin, 2009), other direct accounts linking natural resources and sexual violence come for example from Côte d'Ivoire or Myanmar.

In Côte d'Ivoire, rebel groups operating under the umbrella of Forces Nouvelles from 2002 to 2010 perpetrated various types of violence, including armed robbery, looting, and rapes in order to maintain their domination and extract resources in areas already under their control (Asal and Nagel, 2020). According to Human Rights Watch, "The promise of Ivorian riches was perhaps the main attraction for many coming from Liberia, where a devastated country and civilian population had already been stripped of most resources. [...] The west also held two key assets that were attractive to the Liberians: cocoa and gold." (HRW, 2003a), noting on the following page that "Rape and sexual slavery also occurred on a regular basis by Liberian fighters on both sides. In some cases it appears that rape was used specifically as a weapon of war, with the aim of terrorizing and humiliating the civilian population." As a result, Asal and Nagel (2020) go as far as arguing that "territorial control is an overlooked factor that can increase the likelihood that a group commits sexual violence."

Similar motives appear in countries outside Africa, such as Myanmar. The HRC (2019) notes that in November 2017, "The Tatmadaw attacked several mining operations in KIO/KIA areas of control with an apparent purpose of taking control of economic and natural resources. During various Tanai offensives, Tatmadaw soldiers subjected women to rape, gang rape, attempted rape, forced nudity and sexual humiliation." Although the Myanmar conflict is typically considered to be rooted in purely ethnic grounds, the report notes, "Sexual and gender-based violence have also been committed within the context of the exploitation of natural resources or development projects by the Tatmadaw." The HRC (2019) concludes that "Extreme physical violence, the openness in which it is conducted, and the confidence and general impunity the soldiers enjoy that accompany the Tatmadaw's use of sexual and gender-based violations reflect a widespread culture of tolerance toward humiliation and the deliberate infliction of severe physical and mental pain or suffering on civilians."

Motivated by the above qualitative evidence, this study provides an explanation of the strategic perpetration of sexual violence by armed groups. We retain that sexual violence is predominately a non-lethal form of violence that appears to be exceptionally effective in instilling fear and submitting local populations.

3 Theoretical framework

This research presents a model of violence exerted by an armed group in a region (such as an ethnic homeland) composed of many villages. The armed group relies on civilian production to finance its activities and uses violence as a way to enforce taxation in all villages. Following the background information developed in Section 2, we model sexual violence as a form of non-lethal violence that is extremely efficient in terrorizing local populations. The terror imposed on civilians is key in the model, as the fear of violence increases the expected cost for the civilians to conceal their output from taxation. Therefore, violence allows the armed group to enforce a higher level of taxation at equilibrium. In this section, we derive the equilibrium predictions of the model and highlight its salient characteristics that will guide our empirical approach.

3.1 The setting: Basic structure and timing

We consider a region composed of an armed group and a set of N civilian villages. The interaction between the armed group ($\mathtt{A}$) and the civilians ($\mathtt{C_i}$) is captured through a game in four stages.

Stage 1 - Taxation and violence decisions: The armed group decides for each village i the level of taxation and a *state of violence*: fighters either resort to "non-violence," "non-lethal" violence or "lethal" violence against the civilians in this village.

Stage 2 - Production: The civilians (if "non-violence" or "non-lethal") or the armed group (if "lethal") decide on the optimal level of production in each village.

Stage 3 - Concealing decision: The civilians in each village (if not killed) decide whether or not to "conceal" their surplus.

Stage 4 - Consumption: Tax is collected (on the non-hidden surplus) and consumption takes place in each village.

We assume that (i) the armed group states the type of violence that should be exerted in a specific village[11] and (ii) that enforcing any state of violence requires a higher presence or effort of fighters in the village than the state of non-violence. A state of violence is therefore the combination of fighter presence (or efforts) and a coordination around the type of violence

[11] For example because armed troops explicitly decide to exert sexual violence as a tool of terror, as documented in RDC (Bleasdale, 2009). Our model purposefully abstracts away from the question of within-armed-group principal-agent dynamics (Humphreys and Weinstein, 2006; Nagel and Doctor, 2020) to focus on the interaction between the armed group and the civilian population.

that is to be applied. If lethal violence is exerted, we assume that all civilians are killed (or displaced – as a local version of the strategic mass killing documented in Esteban et al., 2015b). This implies that, in a state of lethal violence, the armed group exploits the resource itself and has to decide about the optimal level of production.

Furthermore, we assume that civilians in each village can conceal the resource from the armed group (or, equivalently, hide part of their labor) to avoid taxation. The expected cost of concealing the resource depends on (i) the nature of the resource, as it is easier to conceal gold nuggets than tons of grains or cobalt, and on (ii) the state of violence decided by the armed group, as it is easier to conceal the resource in non-violent times than when the armed group imposes a high pressure (as in Sánchez De La Sierra, 2020).

Finally, we assume that interactions between the different civilian villages and the armed group occur in a weakly institutionalized region. In particular, this assumption means that the central government has no direct control, and that armed groups can establish illegal monopolies of violence, raise illegal taxes, and run illegal administration systems. This assumption also implies that it is impossible for the civilians and armed groups to credibly establish an ex-ante contract avoiding violence through monetary transfers: the armed group cannot commit to a state of non-violence.[12]

The payoffs The civilians' utility in each village i entails monetary surplus from production of the local resource, the cost of hiding the resource, and the cost of experiencing violence. Civilians trade the tax that has to be paid to the armed group with the expected payoff of concealing the resource:

$$u_{\mathtt{C_i}} = \begin{cases} \pi_i(1-t_i) - \kappa_{\phi_i} & \text{(no concealing)} \\ q_{\phi_i}[\pi_i(1-\delta_{\nu,i})] - \kappa_{\phi_i} & \text{(concealing)} \\ \overline{\pi_i} & \text{(lethal)} \end{cases}$$

where π_i is the surplus generated by production, t_i is the taxation rate and κ_{ϕ_i} is the expected cost of violence, which depends on the state $\phi_i \in \{\mathtt{non\_viol}, \mathtt{non\_lethal}, \mathtt{lethal}\}$. We assume that $\kappa_{\mathtt{non\_viol}} = 0 \leq \kappa_{\mathtt{non\_lethal}} \leq \kappa_{\mathtt{lethal}}$: the cost of experiencing violence weakly increases with the state of violence. We assume that this cost encompasses the psychological cost of violence, which is especially relevant for sexual violence (referring to factors like stigma and ostracism). It is also possible for this cost to be very small if, for example, the workers do not internalize the cost of non-lethal violence exerted on other members of the group (e.g. the

[12]For simplicity, we assume that only one group operates in a specific region. A complicated "Colonel Blotto" game (e.g. Roberson (2006)), where two groups strategically decide to allocate fighters to different battlefields, can then be avoided. These games usually display complicated equilibrium structures that are difficult to test empirically, and that would deviate from the main focus of our analysis, which is studying the interaction between the armed group and the civilians. Our game readily extends to several groups overlapping in a region if the groups do not target the same villages (with enough of them in a region) or if they act non-strategically.

women as victims of sexual violence).

The expected payoff of the civilians if they choose to conceal depends on q_{ϕ_i}, the probability of successfully concealing the resource from the armed group (all the surplus is seized otherwise). This probability depends on the state of violence: $q_{\texttt{non\_viol}} > q_{\texttt{non\_lethal}} > q_{\texttt{lethal}} = 0$. We assume that a higher state of violence decreases the probability to conceal successfully through two mechanisms: (i) a higher fighter presence, which makes it more difficult to conceal the resource or the labor, and (ii) an indirect psychological effect due to the state of fear and submission induced by violence.[13] Similarly, $\delta_{\nu,i}$ is the unit cost of concealing resources, where $\nu \in \{\texttt{easy}, \texttt{hard}\}$ denotes if the resource is easy to conceal or not. Finally $\overline{\pi_i}$ is the payoff if lethal violence is used against civilians (this payoff implicitly contains $\kappa_{\texttt{lethal}}$, and can be negative).

The armed group utility entails monetary benefits from taxation and a cost from exerting violence in each village. In particular, we assume that the aggregate net benefits of exerting illegal taxation in the region is the sum of net benefits across all villages in the region:

$$u_{\texttt{A}} = \sum_{N} u_{\texttt{A},i} \tag{1}$$

The problem for the armed group is therefore to set the tax t_i and the level of violence ϕ_i in each village i in order to maximize its aggregate surplus $u_{\texttt{A}}$. In each village i the armed group chooses the state of violence, trading the higher cost of exerting violence with the benefits of a lower probability for the civilians to conceal the resource:

$$u_{\texttt{A},i} = \begin{cases} \pi_i \times t_i - c_{\phi_i} & \text{(no concealing)} \\ \pi_i(1 - q_{\phi_i}) - c_{\phi_i} & \text{(concealing)} \\ \pi_{\texttt{A},i} - c_{\texttt{lethal,i}} & \text{(lethal)} \end{cases}$$

Increasing the state of violence ϕ_i allows decreasing the probability q_{ϕ_i} of resource concealing in each village, but also increases the cost of exerting violence, which we denote c_{ϕ_i}. We assume that $c_{\phi_i} = F_{\phi,i} \times (w + \epsilon_i)$, where $F_{\phi,i}$ denotes the number of fighters necessary to enforce the state of violence ϕ in village i (with $F_{\texttt{non\_viol}} < F_{\texttt{non\_lethal}} \approx F_{\texttt{lethal}}$), w denotes the per fighter material cost of violence (including factors like soldier wages or weapons), and ϵ_i is the psychological cost of exerting violence (including any historical proximity or hatred between the fighters and the civilians). We assume that the material cost of violence w is similar across all villages in a specific region, for example due to a perfect mobility of fighters

[13] The "means of debilitating, if not annihilating, a population" that Denis Mukwege pointed out in his UNESCO speech. Section 2 and Appendix 8.2 list qualitative and quantitative evidence aligned with the idea that the violence that armed groups impose on civilians may deteriorate the social fabric persistently, annihilating or impeding cooperation among civilians.

that leads to wage equalization in the region. This assumption implies that local shocks on wages are immediately compensated regionally, therefore only large regional economic shocks on wages will impact the cost of violence. However, $c_{\phi_{\mathtt{i}}}$ can also incorporate the price of the resource, if we want to explicitly assume that the price of the local resource impacts fighters' wages (if, for example, fighters are not mobile across villages and recruitment is local). As will be clear in the proof of our main result, this would simply increase the threshold at which we observe violence.[14]

Consequently, $c_{\mathtt{non\_viol}} < c_{\mathtt{non\_lethal}} \approx c_{\mathtt{lethal}}$: exerting violence entails a higher cost than exerting non-violence, as it requires a higher fighter presence F. If the armed group decides to exert lethal violence, the group has to exploit the resource and provide the necessary labor units (as civilians are killed or displaced). The surplus from production is then denoted $\pi_{\mathtt{A},i}$.

The technology. The profit function associated with local resource extraction in each village i is

$$\pi_i = [\alpha e_i + (1 - \alpha_i)R_i] \times p_i - \frac{{e_i}^2}{2} \tag{2}$$

where $[\alpha_i e_i + (1 - \alpha_i)R_i]$ corresponds to the extracted quantity of the local resource, a simple linear function of labor units (e_i) and fixed capital (R_i), and p_i denotes the exogenous local resource price.[15] The resource price is exogenous, as we assume no market power, considering that each village is small with respect to the world market.

For simplicity, we assume that $e_{\mathtt{A}} = 0$ in all villages (meaning that the armed group is unable to provide any productive labor), that R_i is fixed (fixed stock of capital), and that $\alpha_i = 0$ (labor-intensive resources) or $\alpha_i = 1$ (capital-intensive resource). Note that all these assumptions can be relaxed; they only simplify the analysis and avoid having to keep track of too many parameters. If we assume instead that $e_A > 0$, we would observe some lethal violence in labor-intensive areas, as we show in Appendix 8.1. As of assuming that $0 < \alpha_i < 1$, it would imply that we observe some non-lethal violence in capital-intensive areas and some lethal violence in labor-intensive areas.

3.2 Analysis

Below, we solve the Perfect Bayesian Equilibrium of this sequential game. Note that we assume a large pool of fighters in the sense that, given the linear payoff structure, the optimal decision

[14] The right-hand side of conditions 7 and 9.

[15] As will be clear in the analysis section, we can accommodate richer production functions. However, as we do not observe most important parameters of the function (e.g. marginal productivity of labor and capital as well as marginal costs), we choose to keep it simple to highlight the salient mechanisms of the model.

of the armed group relies on taking the optimal decision in each village independently.[16] Proceeding by backward induction, we first study how the civilians' concealing decisions in each village are impacted by the tax and the state of violence decided by the armed group. We then show the optimal resource extraction level for local resources, whether labor-intensive or capital-intensive. Lastly, we analyze how the armed group decides for the optimal level of taxation and the state of violence in each village, accounting for all the subsequent decisions. For brevity, we omit the subscript i whenever the analysis takes place at the village level.

3.2.1 Concealing and optimal taxation in each village

We first analyze the civilians' concealing behavior, conditional on a tax level and a state of violence in a village.[17] From 2 we can see that civilians decide to conceal their surplus if

$$\pi(1-t) - \kappa_\phi < q_\phi[\pi(1-\delta_\nu)] - \kappa_\phi \tag{3}$$

therefore if,

$$t > 1 - q_\phi(1-\delta_\nu) \tag{4}$$

We denote the highest possible tax avoiding concealing by $t^* = 1 - q_\phi(1-\delta_\nu)$. Consequently, if $t > t^*$, the civilians optimally choose to conceal their surplus; while if $t \leq t^*$, civilians do not conceal.

3.2.2 Production decision in each village

We now turn toward the production decision. For simplicity, we focus on two polar cases for the production technology of the local resource: labor-intensive ($\alpha = 1$) and capital-intensive ($\alpha = 0$). We first consider the case of a labor-intensive resource, where labor is the only productive factor. The objective is to maximize

$$Max_{e_i}\ \pi_i(\alpha = 1) = e_i \times p - \frac{{e_i}^2}{2} \tag{5}$$

implying, with our simple functional form, $e_i^* = p$ and $\pi(\alpha = 1)^* = \frac{p^2}{2}$. For a capital-intensive resource ($\alpha = 0$), no effort is exerted and we obtain $\pi(\alpha = 0)^* = R \times p$.

[16] In Appendix 8.1, we discuss the case where the pool of fighters is constrained, implying an allocation choice between the different villages. We discuss how such a spatial (re)allocation would leave our main theoretical prediction unchanged, and would either lead to an attenuation bias in our empirical results or leave them unchanged.

[17] It is noteworthy that the optimal effort (e_i^*) that we will define in the next subsection does not depend on the concealing decision or the taxation, as both only pertain to the total surplus (the tax is non-distortionary).

3.2.3 Taxation and state of violence in each village

We can now study the armed group's decision on the level of taxation and the state of violence, sequentially analyzing the situation of labor-intensive and capital-intensive resources.

The armed group considers three taxation strategies: $t \in \{t^*_{\texttt{non\_viol}}; t^*_{\texttt{non\_lethal}}; 1\}$. We first note that "t=1" is dominated by $t^*_{\texttt{non\_viol}}$ for labor-intensive resources in a state of non-violence as

$$\pi \times t^*_{\texttt{non\_viol}} - c_{\texttt{non\_viol}} \geq \pi \times (1 - q_{\texttt{non\_viol}}) - c_{\texttt{non\_viol}} \tag{6}$$

because $1 - q_{\texttt{non\_viol}}(1 - \delta_\nu) \geq 1 - q_{\texttt{non\_viol}}$.[18] Following the same reasoning, $t^*_{\texttt{non\_lethal}}$ dominates "$t = 1$" in a non-lethal state of violence.[19]

Therefore, it is optimal to set $t^*_{\texttt{non\_viol}}$ in the non_violence state, $t^*_{\texttt{non\_lethal}}$ in the non_lethal state and $t^* = 1$ in the lethal state. The tax level with the highest expected profit will determine the level of violence the armed group chooses.

We first focus on the labor-intensive resource case ($\alpha = 0$):

Result 1 (Non-lethal violence)**.** *For the Labor intensive resource case ($\alpha = 1$), lethal violence is always dominated and the armed group chooses between non-violence and non-lethal violence. The group switches from non-violence to non-lethal violence when*

$$p > \sqrt{\frac{2(c_{\texttt{non\_lethal}} - c_{\texttt{non\_viol}})}{(1 - \delta_\nu)(q_{\texttt{non\_viol}} - q_{\texttt{non\_lethal}})}} \tag{7}$$

and remains non-violent otherwise.

Proof. Comparing strategies on violence, the armed group has to set

$\texttt{violence} \in \{\texttt{non\_viol}; \texttt{non\_lethal}; \texttt{lethal}\}$

and their associated tax level. We can immediately see that lethal is dominated, as $\pi_{\texttt{A}}(\alpha = 1) = 0$ (the armed group is unable to provide productive labor). Consequently, the optimal choice is between $\{\texttt{non\_viol}; \texttt{non\_lethal}\}$. The armed group is better off exerting non_lethal violence than non-violence if $\pi \times t^*_{\texttt{non\_lethal}} - c_{\texttt{non\_lethal}} > \pi \times t^*_{\texttt{non\_viol}} - c_{\texttt{non\_viol}}$, hence if,

[18]Notice that $t^*_{\texttt{non\_viol}}$ brings a higher payoff than $t^*_{\texttt{non\_lethal}}$ in the non-violence state for the same reason.

[19]Naturally, $t^*_{\texttt{non\_lethal}}$ also brings a higher payoff to the armed group than $t^*_{\texttt{non\_viol}}$ in the non_lethal state, as in both cases the civilians are better off not concealing and $t^*_{\texttt{non\_lethal}} > t^*_{\texttt{non\_viol}}$.

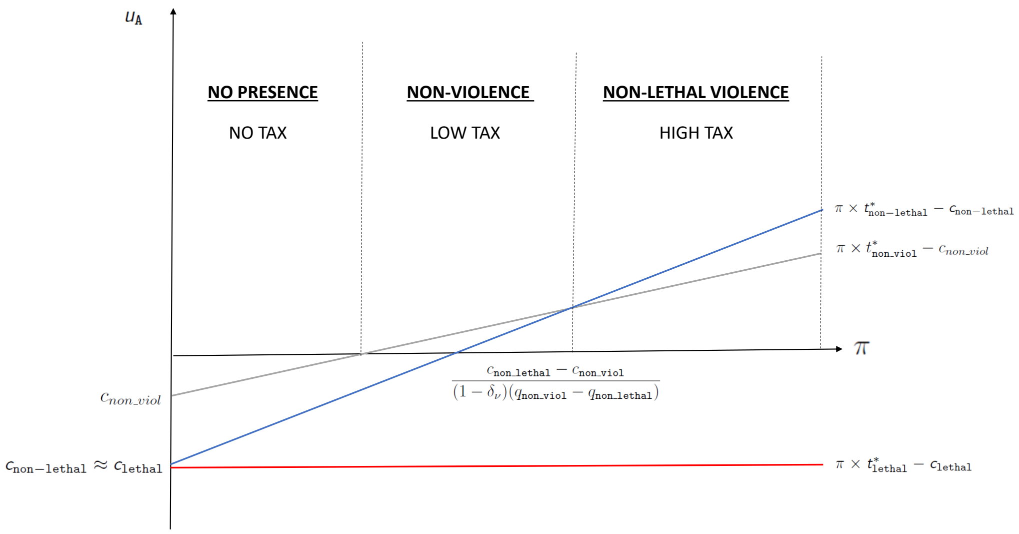
$$\pi > \frac{c_{\texttt{non\_lethal}} - c_{\texttt{non\_viol}}}{(1-\delta_{\nu})(q_{\texttt{non\_viol}} - q_{\texttt{non\_lethal}})} \tag{8}$$

leading directly to condition 7.[20] □

The armed group therefore exerts non-lethal violence when the resource price is sufficiently high to justify giving up on non-violence (as violence allows a higher tax). Condition 7 also highlights that if the resource is easier to conceal ($\nu = \texttt{easy}$), or if the cost of exerting violence against citizens $c_{\texttt{non\_lethal}}$ is lower for the armed group, we should observe more non-lethal violence against citizens. In particular, we observe that if the fighters' wage is lower, we will observe a higher level of violence: a decrease in w will decrease the cost of exerting violence, as $c_{\texttt{non\_lethal}} - c_{\texttt{non\_viol}} = (F_{\texttt{non\_lethal}} - F_{\texttt{non\_viol}}) \times (w + \epsilon_i)$, and increase the level of violence. Figure 1 summarizes the armed group payoff as a function of the profitability of the resource.

Note that if the armed group can provide effective labor units ($e_A > 0$), we can also observe lethal violence around labor-intensive resources. We extend the basic model along this line of argument in the appendix 8.1. In particular, we show that the armed group is more likely to give up on non-violence and exert lethal violence around a labor-intensive resource if the fighters can provide more productive labor. Non-lethal violence remains optimal as long as the differential in labor productivity with civilians remains high.

Figure 1: State of violence – labor-intensive resource and low fighter productivity



[20]The condition 7 depends directly on the functional form of the profit function (especially the linear technology), however Equation 8 highlights that our result linking price and violence will hold qualitatively for more general production functions as long as the profit increases with the resource price (which is generally true, as we assume no market power).

We now turn toward the capital-intensive resource case ($\alpha = 0$):

Result 2 (Lethal violence)**.** *For the capital intensive resource case ($\alpha = 0$), non-lethal violence is always dominated and we observe lethal violence when*

$$p > \frac{c_{\texttt{lethal}} - c_{\texttt{non\_viol}}}{R(1-\delta_\nu)(q_{\texttt{non\_viol}})} \tag{9}$$

and non-violence otherwise.

Proof. In Appendix 8.1 □

To take stock, the incentives to exert violence increase with the profits, therefore, at equilibrium, violence increases with the resource price. Around a labor-intensive resource, the armed group has incentives to preserve labor and is therefore more likely to use non-lethal violence against civilians as the resource price increases. If the armed group is able to provide effective labor, it might also resort to lethal violence. In the vicinity of capital-intensive resources, the armed group has no incentives to preserve labor. Therefore, when the resource price increases, the armed group is better off exerting lethal violence in order to take over the stock of capital and the full surplus. Lastly, we observe that resources that are easily concealed increase the price range for which violence is observed. Graphically, a lower δ_ν shifts the threshold of violence to the left. This implies that high-value and concealable resources (such as gold nuggets) are more prone to violence than agricultural goods (which are harder to conceal).

3.3 From theory to empirics

To bridge the gap toward the empirical estimation of the model, we now discuss the key elements of the armed groups' decision on violence, which appear in conditions 7 and 9. In this discussion we clarify the key assumptions that will allow us to empirically identify the effect of resource prices on the probability of the realization of violence against civilians.

Focusing on the labor-intensive resource case, Figure 1 and Equation 7 show that variations in the resource price will be central in explaining the probability of observing violence, as the profit function directly depends on the local resource price. Equation 7 also highlights that, in order to isolate the relation between the resource price and violence, we want to control explicitly for the other elements in the right-hand side of the equation. To do so, we first have to account for δ_ν, the degree of resource concealability, which we assume to be locality-specific and time-invariant, as it depends directly on the type of resource that is extracted in the cell. Under this assumption, δ_ν is absorbed in a set of *locality-specific fixed effects*.

We also have to account for $(q_{\texttt{non\_viol}} - q_{\texttt{non\_lethal}})$, the differential probabilities of concealing successfully, which we interpret as the ability of the rebel group to monitor local citizens under both states of violence. We assume that this monitoring ability is composed of a set of time-invariant local characteristics (such as local geography, the nature of the resource, and size of the village, which are absorbed in the locality-specific fixed effects) and a set of characteristics specific to each armed group active in a given area a given year (like its knowledge of the area, cultural proximity with workers, and number of fighters). Building on the literature emphasis on the importance of inter-ethnic traits and tensions in driving internal conflicts, including sexual violence (e.g. Guarnieri and Tur-Prats, 2020; Reynal-Querol, 2002; Rohner et al., 2013), we assume that the later term is absorbed by a flexible set of *ethnic homeland* $\times$ *country* $\times$ *year fixed effects*.

Lastly, we have to consider $(c_{\texttt{non\_lethal}} - c_{\texttt{non\_viol}})$, the differential cost of exerting violence in both states of violence. In the theoretical framework, we assumed that this cost is composed of two parts. First, there is a material part that depends on macro conditions that vary at the country-year level (wages of fighters that impact the opportunity cost of fighting, but also the state capacity, institutional quality, etc.), or at the ethnic group-year level (such as the political standing of a specific ethnic group in a specific year, which may impact local institutional quality through ethnic favoritism, Hodler and Raschky, 2014). Second, there is a psychological part, which we relate to the cultural and ethnic distance between the perpetrators and the victims. We assume that this distance varies over time at the ethnic group level, as recent evidence highlights that ethic identity and ethnic hatred may be affected by economic shocks or manipulation by ethnic or political leaders (e.g. Berman et al., 2020a; Blouin and Mukand, 2019; Yanagizawa-Drott, 2014). We therefore consider that these components are absorbed in our rich set of *ethnic homeland* $\times$ *country* $\times$ *year fixed effects*.[21]

4 Data sources and patterns

To assess the impact of local economic resources on the use of violence against civilians empirically, we combine data on (i) the location and incidence of violence, (ii) the location of different economic resources, and (iii) how the value of these resources varies over time.

Our unit of analysis is a full grid of African countries divided in cells of size 0.5 $\times$ 0.5 degrees. The widely used cell level of analysis allows us to abstract away from the endogenous design of subnational administrative borders (Berman et al., 2017; Besley and Reynal-Querol, 2014; Manacorda and Tesei, 2020). The cell contours do not typically correspond to a country's political borders. To ensure that we account for the relevant country-year level changes in reporting sexual violence events or media attention, we cross the cells with national country borders.[22] Overall, we cover 12,906 cells $\times$ country units (based on 10,678 cells).

[21] The analysis is similar when considering Equation 9 for the determinants of lethal violence. The only difference is the addition of the fixed stock of capital R , which is absorbed in the locality fixed effects.

[22] Our results remain unchanged if we omit cells that are split between different countries.

4.1 Violence

The ACLED Our explained variable comes from the latest release of the widely used Armed Conflict Location and Event Dataset (ACLED, Raleigh et al., 2010). The data covers the entire African continent over the period 1997 to 2018. For each violent event, it gives the precise date and place (the exact or nearest town or village where the event took place ACLED, 2019). Out of the full sample of 237,175 events, we exclude from our analysis the 8,579 events for which the geoprecision is unsure, as well as the 10,093 events for which geocoordinates are missing. The data is manually coded from daily information originating from local, regional, national and continental media. NGO reports supplement media reporting in cases that are hard to access. Recent papers exploit the high disaggregation of the ACLED in time and space, some specifically linking conflicts to natural resources (like Berman et al., 2017; McGuirk and Burke, 2020), others linking conflicts to a wider range of topics (such as Besley and Reynal-Querol, 2014; Depetris-Chauvin et al., 2020; Manacorda and Tesei, 2020; Michalopoulos and Papaioannou, 2016).

Three original features of the ACLED are crucial in our analysis. First and foremost, the most recent version of ACLED classifies all the events into various events and subevent types, where "sexual violence" is one of the subevent types. Second, for all events the data classifies the type of actors involved in the event. This feature allows us to isolate which are the violent events that are (i) perpetrated by armed groups and (ii) target civilians. Third, the data records events *independently* of whether they lead to fatalities, and separately records the eventual number of fatalities.

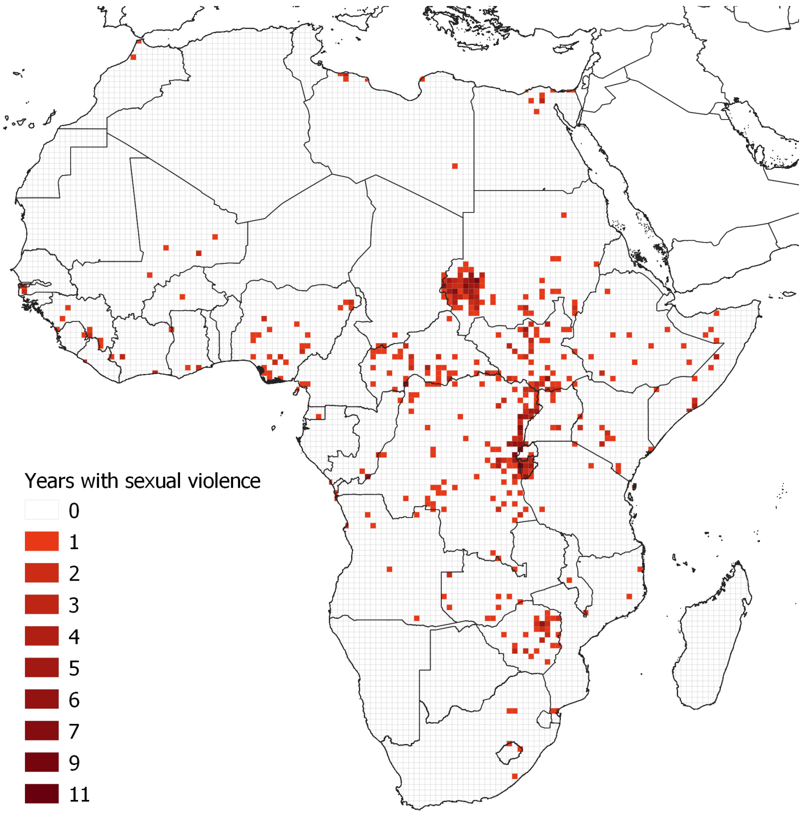
Sexual violence We first investigate the determinants of sexual violence, as recorded in the ACLED. The ACLED, 2019 notes that "This subevent type is used when any individual (regardless of gender) is targeted with sexual violence. 'Sexual violence' is defined largely as any action that inflicts harm of a sexual nature. This means that it is not limited to solely penetrative rape, but would also include actions like public stripping, sexual torture of men, etc." The ACLED started recoding sexual violence in a specific subevent in 2019.[23] To ensure that this subevent is consistently coded as such through the earlier years of the dataset, the ACLED team manually went through all the previously coded events.

The data recorded 2,207 events of sexual violence in African countries between 1997 and 2018. All events are perpetrated by armed groups against civilians, and 76.67% of the events led to zero fatality.[24] We aggregate these events at the cell $\times$ country $\times$ year level, coding a variable of sexual violence incidence that is equal to one if any event of sexual violence that

[23]As sexual violence in conflict settings is ultimately a form of conflict violence, it had always fallen within ACLED mandate. In data released previously, sexual violence appeared as one of the many forms taken by "violence against civilians" instead of being signaled out by a specific subevent category.

[24]We drop from the sample the five events of sexual violence perpetrated by the actor "rioters".

Figure 2: Number of years of the sample during which the cell witnessed sexual violence



took place in that cell and country that year. As some places are targeted by repeated events in a single year, we later also consider the number of distinct events of sexual violence. Figure 2 gives a first visual overview of where sexual violence events took place, and how often they occurred.

We favor the ACLED over the Sexual Violence and Armed Conflict Database (GEO-SVAC) due to our research question. The GEO-SVAC, based on UCDP GED database, records sexual violence *possibility* at the level of the conflict-actor-year level from 1989 to 2009. Put differently, if an armed actor is known to have once used sexual violence during one year, all the UCDP GED events in which this actor participated that year will be coded in GEO-SVAC as events of sexual violence – irrespective of whether those events included sexual violence. As a result, while the GEO-SVAC provides crucial data for analysis and research questions centered on the characteristics of the perpetrating actors (the armed groups), it is less relevant for a research question related to local conditions. Our question takes place on the actor-year level, as we want to document why a given actor perpetrates sexual violence in a specific place. The precise georeferencing of sexual violence in the ACLED is key in answering this research question. The ACLED also has the value-adding features of being more recent and covering a longer time period than the GEO-SVAC.

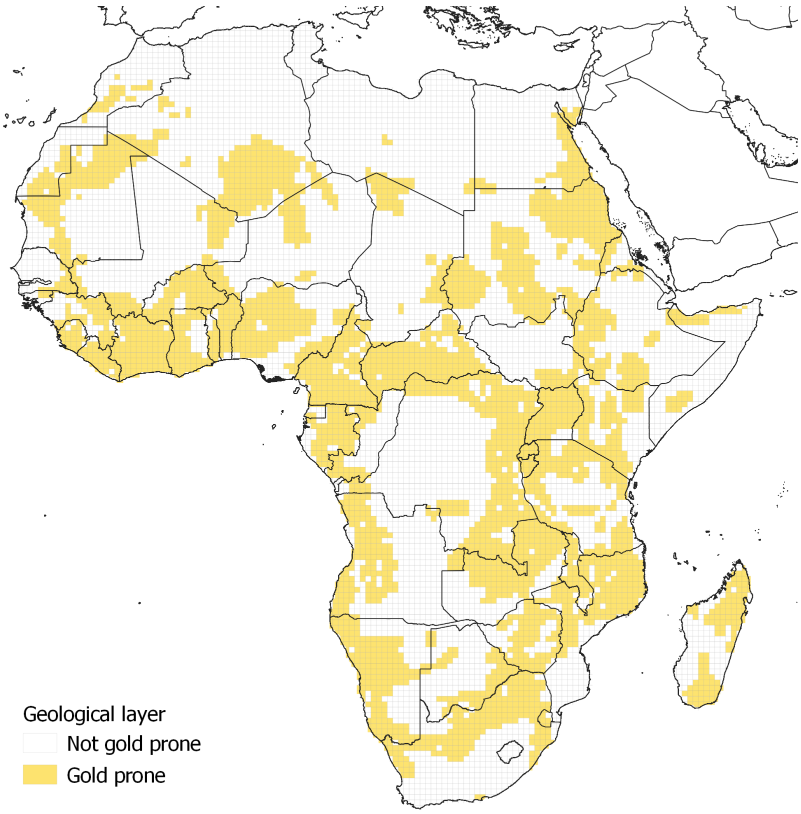
We also acknowledge that the ACLED is likely to have limitations in the recording of sexual violence due to the fact that sexual violence is mostly non-lethal, considered as highly stigmatizing, and its media perception may have changed over time. A first crucial observation is that we work on sexual violence perpetrated in conflict settings, which means that the events we focus on are more public in their nature and intention than events of intimate partner sexual violence. We also note that our data stops in the year of the Nobel Prize attribution to Denis Mukwege and Nadia Murad, limiting the risk of a discontinuous increase in media attention generated by this event. Moreover, any country-specific change in media attention would be absorbed by our fixed effects. Nevertheless, to increase the confidence in the empirical patterns we document, we also show that our theoretical predictions hold for other categories of violence that do not suffer from the same potential stigma and media attention as sexual violence.

Lethal and non-lethal violence The structure of the ACLED allows us to check that the drivers of sexual violence match the drivers of other forms of non-lethal violence against civilians, and differ from the drivers of lethal violence. To do so, we define two variables that indicate the incidence of lethal and non-lethal violence by armed groups that target civilians. We proceed in three steps. First, we consider all the ACLED subevent categories that involve both civilians and armed groups (we therefore drop all other subevents). These subevents are: Abduction/forced disappearance, Air/drone strike, Arrest, Attack, Chemical weapon, Grenade, Looting/property destruction, Other remote explosive/landmine/IED, Sexual violence, Shelling/artillery/missile attack, Suicide bomb. Second, we compute the share of events where at least one fatality is recorded in each subevent category. These shares appear in Appendix Table A-4. While the measure of fatalities event by event is most likely plagued by errors, we interpret the significant differences in the share of fatalities in each subevent type as informative with respect to how likely a subevent type is to be lethal. Third, we split the subevents depending on how often they are lethal, using a cutoff at 50%. For example, there is a fatality record in 23.37% of the sexual violence events – we therefore include sexual violence in the broader category of "non-lethal violence." At the opposite end, there is a fatality record in 58.90% of the attack events – we therefore include attacks in the broader category of "lethal violence."

4.2 Local resources

We consider three sources of local income: artisanal mining, industrial mining, and agriculture. Our motivation in the selection of these resources is twofold. First, we want to directly test the relation between the strategic use of sexual violence and the presence of mineral resources highlighted, for example, by Denis Mukwege. Second, building on our theoretical framework, we are interested in how the price of resources that differ in their labor-intensity and concealability relate to sexual violence. Taking the example of gold, artisanal mines employ 90% of the gold mining sector workforce, but 80% of the gold production comes from industrial mines (IGF, 2017). We therefore want to account for both types of mining activities. These two sec-

Figure 3: Artisanal mines: gold-prone geological layers



tors appear as extreme examples of a labor-intensive and a capital-intensive sector, as outlined in our theoretical model. Both sectors produce comparable outputs, namely minerals that can be concealed. Gold mines alone represent the main mineral being produced in a cell for 36% of the cells hosting an industrial mine. To fully apply our model to the data, we also consider agricultural activities, with labor-intensive production that is harder to conceal than minerals. According to the World Bank's World Development Indicators, this sector has employed more than 50% of the population in Sub-Saharan Africa since 1998.

Artisanal mining Measuring artisanal mining activities (ASM) is notoriously difficult, as no comprehensive data exists to date. As a highly mobile and often informal activity, artisanal mining is difficult to capture through administrative data, and survey data cannot ensure the continent-wide coverage that we target. To overcome this challenge, we resort to a new dataset assembled by Girard and Vic (2020) for artisanal gold mining. We follow the focus of Girard and Vic (2020) on artisanal gold mining, since it is by far the main form of artisanal mining in Sub-Saharan Africa: artisanal gold mining represents more than 95% of artisanal sites in West Africa (Tyschen J., 2019). From data available across the continent, 54% of the ASM workforce works in countries where the ASM sector extracts only gold, and 88% in countries where the ASM sector extracts either gold alone, or mostly gold (Hilson, 2016, country-wide numbers appear in appendix Table A-6).

Our proxy for artisanal mining activities rests on two sources of variation: space and time. The space variation comes from geological bedrocks (Girard and Vic, 2020); it extends to the entire continent the approach of Bazillier and Girard (2020), indicating which ancient geological strates and lithologies are prone to hosting gold from the map of Thiéblemont et al. (2016). This procedure results in a dummy variable that equals 1 for places above a geological bedrock prone to hosting gold, and 0 elsewhere. Figure 3 shows all cells overlapping with one of these gold-prone bedrocks.

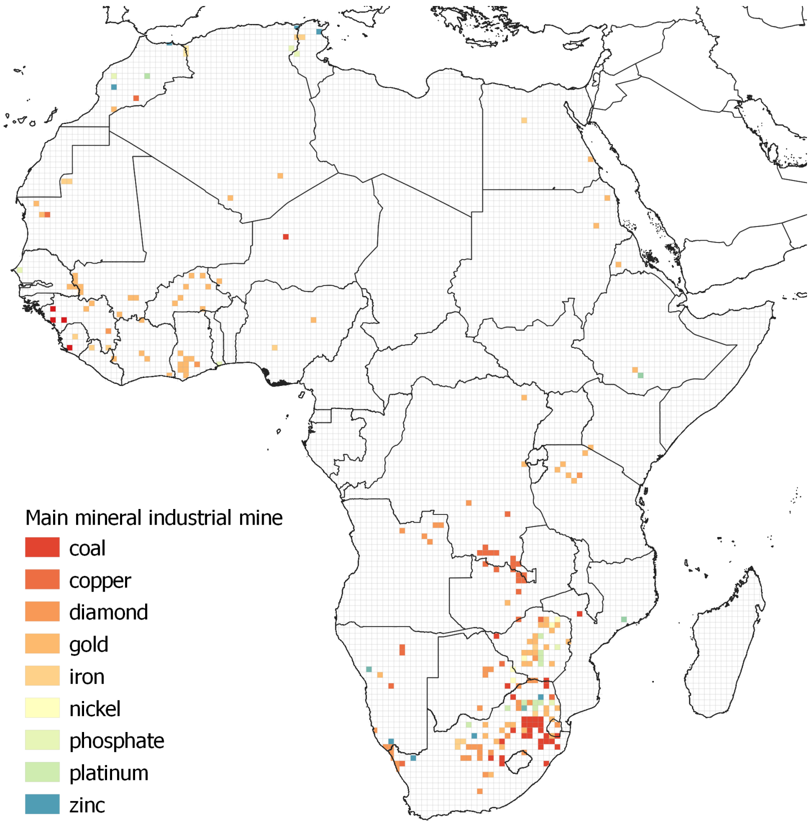
The time variation comes from the international gold price. The core idea is that, everything else being equal, an increase in the international gold price should intensify the effect of artisanal mining activities, be it because of an increase in work intensity or because more miners join the activity. Gold miners are pricetakers on the international gold market and are typically paid a price that closely mirrors the international price for their gold (see Alvarez et al., 2016; Balme and Lanzano, 2013; Sánchez De La Sierra, 2020). This procedure results in a measure of artisanal mining activities that varies across time and space. To ensure comparability, we transform the gold price series from the World Bank data into an index base 1 in 2013. Crucially, while coarse, Appendix 8.3 reports results from Girard and Vic (2020), indicating that this proxy of artisanal mining correlates positively with the likelihood that local workers work in the extractive sector (using data from the Demographic Health Surveys) and to local night light intensity (a proxy of local economic activity).

This artisanal mining proxy has two main advantages. The first is its continent-wide coverage. The second is its exogeneity to violence in a given cell $\times$ year. However, these advantages come with noise in measurement, as not every gold-prone geological bedrock hosts an artisanal mine, and some secondary artisanal mines may lie outside the gold-prone geological layers (for example because a river carried away part of the ore). We also acknowledge that any such contamination of the "control" and "treatment" samples will lead to attenuation biases of our results.

Industrial mining For industrial mining, we use the data of Berman et al. (2017) that we extend to 2018. Berman et al. (2017) define a cell as being a "mining cell" if it contains an active industrial mine in 1997 (the beginning of the sample). For each cell, Berman et al. (2017) define the "main mineral" as the one with the highest industrial production over the period, evaluated at 1997 prices. Figure 4 shows the location and type of main minerals over the continent, Table A-5 shows the corresponding statistics. Berman et al. (2017) note that among the 237 mining cells for which they identify a main mineral, 70% produce a single mineral, and the main mineral produced represents on average 96% of the total production value.

The international price of each mineral is associated to each cell where this mineral is the main one. This procedure gives us a time- and space-varying measure of the value of industrial mining production. We update the price series data used in Berman et al. (2017) until 2018,

Figure 4: Main mineral extracted

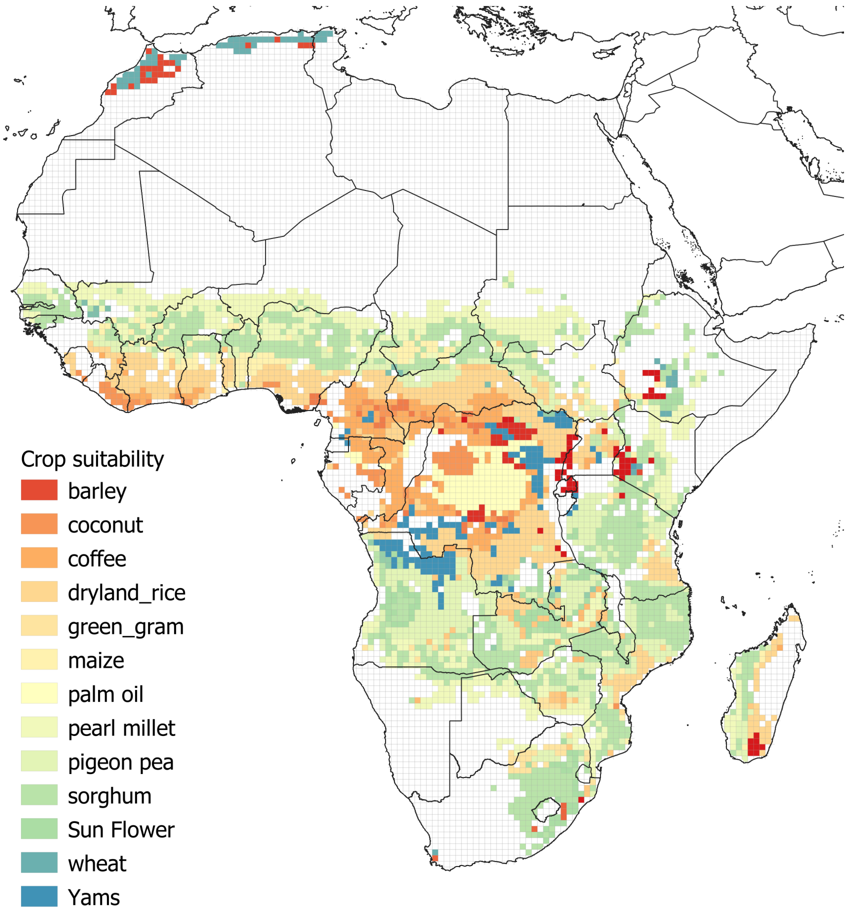


with World Bank commodity data prices. To ensure comparability, we take each mineral price series as an index base 1 in 2013.

This (updated) measure of industrial mining activity has the main advantage of being most likely exogenous to our outcome of interest. We would be more concerned about reverse causation if we relied on industrial mines opening or closing, which might be affected by conflict events. Instead, the measure we use ensures that the coefficient of industrial mines will be identified in cells through changes in world commodity prices, conditional on the cell-time-invariant characteristics. Moreover, we consider each cell to be a pricetaker on the international mineral market. All the countries in our sample typically are small producers from a world perspective. Aggregating these cells observations as the country level, Berman et al. (2017) report that the average market share of a country mineral is around 6.5% (the median is 2.9%).

Agriculture The last local resource we consider is agriculture. Mirroring the construction of the artisanal mining data, we combine information on a cell crop suitability with the crop price. Based on the FAO's Global Agro-Ecological Zones (GAEZ), which indicate a cell level suitability for different crops, we identify the crop(s) for which the cell is most suitable. To consider a cell as suitable for the cultivation of at least one crop, we follow Nunn and Qian (2011), focusing on cells the GAEZ classified as "very suitable", "suitable" or "moderately

Figure 5: Main suitable crop for the cell



suitable." Concretely, this means that we consider as improper for agriculture any cell where none of the crop the GAEZ considered can reach 40% or more of its potential yield under rain-fed conditions and medium-input intensity. Of the African cells, 4,899 are suitable for at least one crop, and 91.24 % have a single main crop for which they are most suitable.[25] The crops are listed in Table A-7, and Figure 5 represents spatially which crop is considered the most suitable for each of the cells, having at least one crop that is moderately to highly suitable.[26]

For the time variation, we associate to each crop the international price series of that crop, taking an index base 1 in 2013. The price series data comes from the UNCTAD (available at the WITS portal of the World Bank). We collapse prices at the crop $\times$ year level to obtain one yearly world price series for each crop.

[25]For the other cells, which have a maximum suitability for more than one crop, we take into account the average of the price indexes of each of these crops.

[26]As a robustness exercise, we also consider the main crop being produced in each cell. Our main results rest on agricultural land suitability because it is arguably more exogenous, mirroring the definition of the artisanal mining proxy.

4.3 Summary statistics

Our final sample covers 53 African countries from 1997 to 2018. Over this period, 34 countries have witnessed some sexual violence, 46 countries overlap with part of a gold-prone geological layer (our proxy for artisanal mining), while 30 countries have at least one industrial mine active at the beginning of the period.

Table 1: Descriptive statistics

Variable	Mean	Std. dev.	Min	Max
Panel A: ACLED events incidence				
Sexual violence	0.003	0.051	0	1
Non-lethal violence	0.012	0.111	0	1
Lethal violence	0.040	0.195	0	1
Battle	0.040	0.196	0	1
Panel B: Local economic conditions				
Artisanal price shock	0.260	0.368	0	1.183
Industrial price shock	0.012	0.099	0	2.473
Agricultural price shock	0.325	0.418	0	1.671

N = 273,868. Each price comes from an index rescaled to be base 1 in 2013

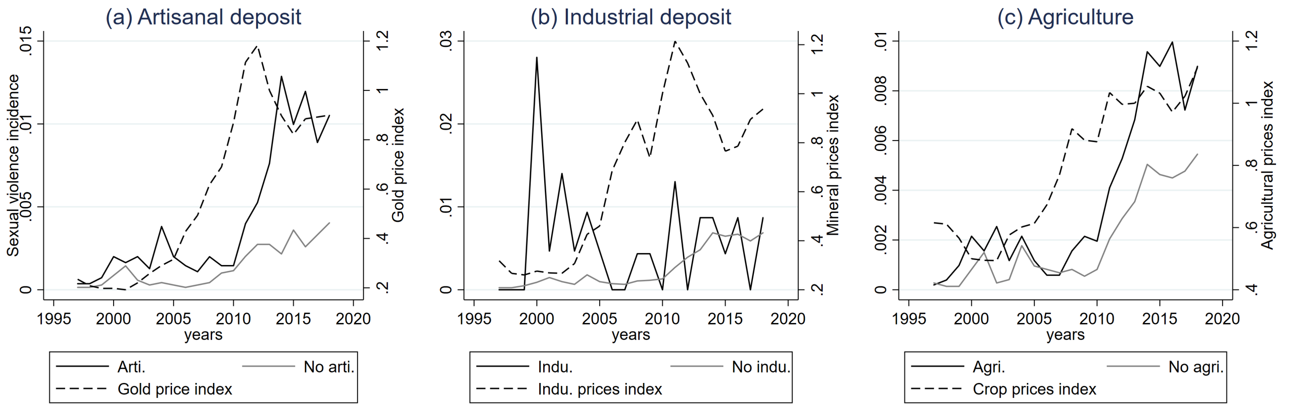
4.4 Data visualization

For a first overview, Figure 6 shows the raw relation between local resource availability and the incidence of sexual violence. The three panels do not aim at displaying a causal story: they do not control for any of the crucial aspects discussed in Section 3.3, such as the sociocultural proximity between the armed group and civilians, or the evolution of state capacity and macroeconomic conditions. We will control for the corresponding fixed effects in the remainder of the paper. Before doing so, Figure 6 allows us to get a sense of the patterns in the raw data.

Cells that are prone to artisanal mining appear to have witnessed a surge in sexual violence between 2010 and 2014, and a stabilization after 2014 (Figure 6 Panel A). Cells that are not prone to artisanal mining see a slow and steady increase over the period. The growth in the incidence of sexual violence over the period in cells with artisanal mining mirrors with a lag of a few years the evolution of the global gold price, which started increasing in 2005, before slowly stabilizing or decreasing from 2011 onward.

In contrast, in Figure 6 Panel B we see a decline in the incidence of sexual violence in cells that host industrial deposits. Cells that do not host industrial mining see a slow and steady increase over the period. The growth in the incidence of sexual violence over the period in

Figure 6: Sexual violence incidence over time, by type of local economic resource



either type of cells does not appear to follow the prices of minerals being extracted in the cells that host industrial mines.

Lastly, Figure 6 Panel C documents that cells that can host agricultural activities witness a surge in the incidence of sexual violence between 2010 and 2014, and a stabilization after 2015. Cells that do not host agriculture also see a surge in sexual violence between 2010 and 2014, although of a smaller magnitude than in agricultural cells. The growth in the incidence of sexual violence over the period in both types of cells loosely follows the prices of the crops being produced in agriculture-prone cells, as these prices steadily increase over the period.

5 Identification strategy

Our aim is to empirically investigate the relation between resource prices and the incidence of sexual violence. To identify this relation, we build on Equation 7 and estimate the following equation :

$$\begin{aligned} Y_{ict} = {} & \alpha_1 \text{Artisanal price shock}_{ict} \\ & + \alpha_2 \text{Industrial price shock}_{ict} \\ & + \alpha_3 \text{Agricultural price shock}_{ict} \\ & + FE_{ic} + FE_{ect} + \varepsilon_{ict}, \end{aligned} \tag{10}$$

Where Y_{ict} is a dummy variable that equals 1 when sexual violence takes place in cell i, in country c, and year t. Artisanal price shock $_{ict}$ is our proxy of artisanal mining activities: for cells prone to hosting artisanal gold mines, it takes the value of the international gold price index (coming from Girard and Vic, 2020). Industrial price shock $_{ict}$ is the price index of the main mineral exploited by the industrial mines in the cell (updated from Berman et al., 2017). Agricultural price shock $_{ict}$ tells the price index of the crop for which the cell is most suitable (the suitability measure was first used by Nunn and Qian, 2011). Section 4 discusses each measure in more detail. To be able to compare the time variations of each price that is initially expressed for different quantities, we transform each price series as indexes with a base 1 in 2013.

Following the discussion regarding Equation 7 (in Section 3), the cell $\times$ country fixed effects FE_{ic} account for any cell and country-specific features, such as the degree of concealability of the local resource, remoteness or distance to borders, topology, historical ethnic composition of the local civilian population, and any other time invariant feature that might affect violence as well as mining activities. The demanding ethnic homeland $\times$ country $\times$ year fixed effects FE_{ect} account for any time-varying changes at the country and ethnic group level, including state capacity, macro conditions (wage level), active rebel groups, lack of institutional capacity of central states, change in ethnic groups' political power balance, ethnic hatred, etc. We define these fixed effects using the homeland borders from the most conservative versions of the 2013 and 2019 Ethnic Power Relations Dataset (EPR, Vogt et al., 2015; Wucherpfennig et al., 2011), which contains time-varying information on ethnic homeland boundaries until 2017, as well as on political power.[27] We account for spatial correlation in all specifications by estimating standard errors with a spatial HAC correction, allowing for both cross-sectional spatial correlation and location-specific serial correlation (Conley, 1999; Hsiang et al., 2011), using the Stata routine Collela et al. (2018) developed.[28]

Following the conflict literature with highly disaggregated data when using a binary dependent variable, we rely on a linear probability estimation (e.g. Almer et al., 2017; Berman et al., 2017; McGuirk and Burke, 2020; Michalopoulos and Papaioannou, 2016). Our baseline specification replicates the predictions of the model accounting for the three resource variables. Based on the model, we expect α_1 to be strongly positive, as we expect a strong predatory effect when the price of gold increases around artisanal mines, as it is a labor-intensive resource that is easily concealed. We expect α_2 to be null or negative as industrial mines are capital-intensive, and it is therefore expected that armed groups substitute lethal violence for non-lethal violence when the price of this resource increases (in order to appropriate the whole output and the capital needed for extraction). Finally, we expect α_3 to be zero or weakly positive, as crops are labor-intensive, but more difficult to conceal than gold.

We also account for the idea that sexual violence might sometimes be a potential "byprod-

[27]The Geo EPR data defines homelands that can vary over time and overlap spatially with each other. If two homelands partly overlap in one part, we define three levels of fixed effects: one for each homeland outside the overlap, and one dedicated to the overlap. Figure A-2 shows the homelands' shapes.

[28]Similar to Berman et al. (2017), who note that this is a demanding treatment, we impose no constraint on the temporal decay for the Newey-West/Bartlett kernel that weights serial correlation across time periods. This means that we allow serial correlation to vanish only at an infinite time horizon (represented by 100,000 years). For the spatial kernel, we consider a radius of 500 km because this is close to the median internal distance in our sample of countries (according to the CEPII geodist dataset).

uct" of conflict, for example if sexual violence is a systemic side effect of battles, as a way to reward combatants. To do so, we alternatively omit or include a control for the occurrence of battle events, or of any sort of violent ACLED event (other than the sexual violence events themselves). We control for battles, or more generally for violent events, in order to check that the relation we pick up between local resources and sexual violence does come from a taxation strategy rather than from an omitted variable bias given the strong relation between local economic resources and local conflicts (documented in Berman et al., 2017; Dube and Vargas, 2013; McGuirk and Burke, 2020). We do not systematically control for these forms of violence, as one may worry that it is a bad control. We show in the next section that our coefficients of interest remain perfectly stable when we control for battles, as well as when we control for more general forms of ACLED violence.

6 Results

6.1 Local resources and sexual violence: baseline results

Table 2 displays our baseline results on sexual violence. It shows how the incidence of sexual violence reacts to each resource's global price variations, for cells endowed with artisanal gold mining potential, industrial mining activities, or agricultural potential. We first document the relation between sexual violence and each local resource variable taken alone (Columns 1 to 3), and then jointly introduce all resource variables (Column 4). The coefficients remain remarkably stable across the single and joint specifications.

In line with our theoretical predictions, a positive artisanal price shock increases the perpetration of sexual violence (Columns 1 and 4). A one standard deviation increase in the price of gold extracted artisanally is associated with a 0.002 increase in the incidence of sexual violence. As the average incidence of sexual violence in the sample is 0.003, this coefficient suggests that artisanal mining prices are an important quantitative determinant of sexual violence. In contrast, there is no consistent effect of price shocks in cells that host industrial mining or agricultural activities (Columns 2, 3, and 4).

Lastly, in Columns 5 and 6, we control for the incidence of other forms of violence in the cell in order to investigate their possible mediator effect. Consistent with the idea that these other forms of violence may trigger sexual violence, we observe a significantly positive relation between sexual violence and the incidence of either battles or all ACLED events. However, the coefficients of each of the price shocks for the three local resources remain stable between Column 4 and Columns 5 or 6. This stability suggests that while battles – and more generally any form of ACLED violence – are associated with sexual violence, they are not a significant mediator of the relation between resource prices and sexual violence.

Table 2: Main results: Staggered introduction of the resource variables

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Sexual violence						
Artisanal price shock	0.0054^{a}			0.0055^{a}	0.0055^{a}	0.0054^{a}
	(0.001)			(0.001)	(0.001)	(0.001)
Industrial price shock		-0.0034		-0.0049	-0.0053^{c}	-0.0063^{b}
		(0.003)		(0.003)	(0.003)	(0.003)
Agricultural price shock			0.0025	0.0025	0.0027	0.0024
			(0.002)	(0.002)	(0.002)	(0.002)
Battle incidence					0.025^{a}	
					(0.003)	
Violence incidence						0.014^{a}
						(0.002)
Cell × countries FE	Y	Y	Y	Y	Y	Y
Year × ethnic group × countries FE	Y	Y	Y	Y	Y	Y
Observations	273867	273867	273867	273867	273867	273867

LPM estimations. Standard errors in parentheses. ^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01. Conley (1999) standard errors in parentheses, allowing for spatial correlation within a 500 km radius and for infinite serial correlation. The dependent variable is a dummy variable that equals 1 if any event of sexual violence is observed in that cell-country-year level.

6.2 Local resources and sexual violence: allowing a non-linear relation

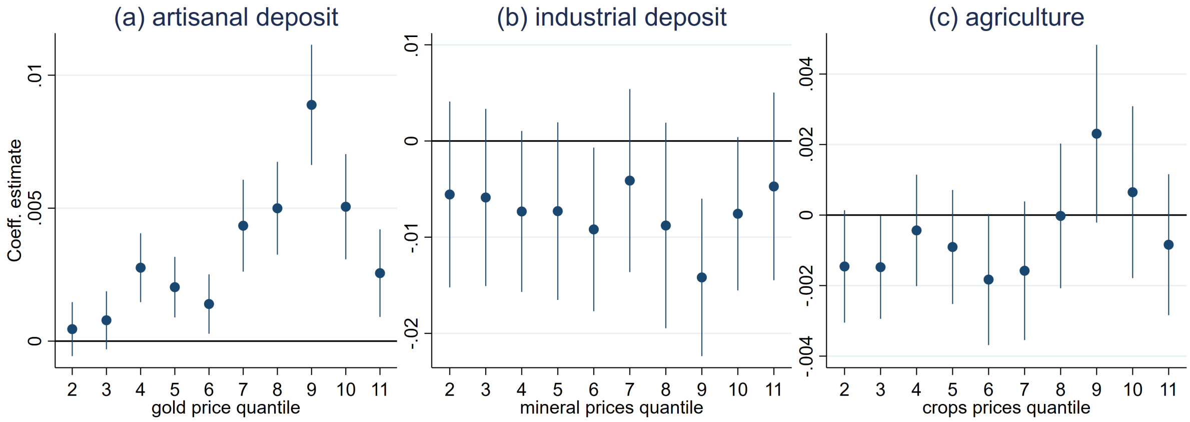
We now turn toward the estimation of a possible non-linear relation between local economic resources and the incidence of sexual violence. Specifically, we investigate the existence of a threshold effect, a resource price after which the "predatory" effect identified in our theory would increase substantially. We reestimate Equation 10 after breaking each of the three price indexes (one for each of the three resource variables) into dummies that are each equal to 1 for the different quantiles of the price. Figure 7 displays the results. We see that the incidence of sexual violence increases with the gold price quantiles, with a significant discontinuity between the sixth and seventh quantiles (Panel A). Moreover, the relation between sexual violence and artisanal mining is significantly positive for all prices from the seventh price quantile onwards. We observe no such discontinuity at any of the quantiles of minerals mined industrially (Panel B), nor for agriculture (Panel C).

Overall, these baseline results are consistent with a strategic use of sexual violence by armed groups, targeting artisanal mining exploitation for taxation.

6.3 Robustness

Our baseline results are robust to a variety of sensitivity checks. First, we note that our results remain unchanged when we include various sets of controls: population density, local economic conditions (gross cell product) and local land features, or all these jointly. The results appear

Figure 7: Flexible relation between resource prices and sexual violence



Note: Each point in Panel A represents the coefficients of a dummy variable that equals 1 in artisanal mining areas for the different quantiles' values of the gold price, while points in Panels B and C indicate the equivalent for industrial mines or agricultural prices. The coefficients of all three panels are estimated jointly, from the following equation: $Y_{ict} = \sum^q \alpha_1^q \text{Artisanal deposit}_{ic} \times \text{gold price}_q + \sum^x \alpha_2^x \text{Industrial deposit}_{ic} \times \text{mineral prices}_x + \sum^z \alpha_3^z \text{Artisanal deposit}_{ic} \times \text{crop prices}_z + FE_{ic} + FE_{ect} + \varepsilon_{ict}$, in order to identify the effect of artisanal mining for each quantile q of the gold price, of industrial mining for each quantile x of the mineral prices, and of agriculture for each quantile z of the crop prices. We consider 11 quantiles of equal size, as we have 22 years. The first quantile systematically drops from the estimation due to collinearity. The figure represents the coefficients estimated for the 10 other quantiles. Bars around each point represent the 90% confidence intervals.

in Table A-8.

As we focus the analysis of artisanal mines on gold mines, we check whether the patterns we document are specific to gold extraction in general, be it artisanal or industrial gold extraction. To do so, we split the sample of cells that host industrial mines to isolate the cells where the main industrial mine is a gold mine. The results in Column 1 of Table A-9 are very similar to our baseline: if any, a price shock in industrial gold mines would have a negative relation with the incidence of sexual violence. Moreover, the coefficient of industrial gold mines cannot be statistically distinguished from the coefficient of other industrial mines. These results are inconsistent with a specificity of gold extraction driving our baseline results. Recent literature highlights that the cohabitation of industrial and artisanal gold mining may lead to particularly tense dynamics (Bazillier and Girard, 2020; Stoop et al., 2019). We therefore check for a potential change in the relation between industrial mines and violence, depending on whether we account for the potentiality of artisanal mining. The results in Column 2 of Table A-9 are once again aligned with our baseline results and are remarkably similar to those in Column 1, albeit more precisely estimated. This observation contradicts the idea that our results would be based on gold extraction in general by emphasizing the importance of the labor intensity of the extraction technique used.

We also consider an alternative measure of agricultural activities provided in GAEZ. The relation between sexual violence and the artisanal price shock remains unchanged when we measure agricultural activity with the main crop actually being produced in the cell (Columns 3 and 4 of Table A-9). The relation between agriculture and sexual violence becomes more accurately estimated. This approach differs from our baseline, where we take the prices of the crop for which the soil is most suitable, as it is an exogenous measure of agricultural activity.

As one may consider alternative approaches to tease out the relation between resources and sexual violence, each levying alternative sources of variations, we change the specification of the equation we estimate. The results are unaffected when defining our fixed effects with the more ancient Mira map for ethnic homelands instead of the existing EPR homelands (Column 1 of Table A-10). The results are also robust to using the standard country $\times$ year level instead of our demanding ethnic homeland $\times$ country $\times$ year fixed effects (Column 2 of Table A-10). We confirm that the results are unaffected by the presence of cells split between different countries (Column 3 of Table A-10)

We also note that we used the DRC as our motivating example, but a country that has been called "the rape capital" might be an outlier (Lloyd-Davies, 2011). We therefore check that our results are not driven by the DRC alone by dropping that country from the sample. The estimates remain statistically robust to this exclusion exercise (Column 4 of Table A-10). This confirms that the pattern we unveil between violence and natural resources is consistent with the strategic use of sexual violence by actors also outside the DRC, in line with the case studies mentioned in Section 2.

Finally, while our theoretical model is silent on the intensive use of sexual violence, we also consider the intensive rather than the extensive margin of violence. We obtain results consistent with our baseline results (Column 5 of Table A-10).

6.4 Local resources and the typology of violence

To ensure that our baseline specification captures fundamental features of the relation between the value of local resources and sexual violence, and following our theoretical predictions, we turn to a broader study of the typology of violence. Theoretically, we considered sexual violence as a strategic non-lethal form of violence used by armed groups. If this holds, we should observe a similar relation between local resources and other forms of non-lethal violence: artisanal (labor-intensive) mines should be the prime driver of non-lethal violence, whether sexual or non-sexual. In contrast, industrial mines (capital-intensive) should be the prime driver of lethal violence.

This exercise also allows us to make sure that our results are not driven by a biased measure of sexual violence. We can think of two main potential sources of bias in the measure of sexual violence that would affect our results: (i) an increase in media attention dedicated to sexual violence, or (ii) a change in social acceptability to report it over time. We believe that these two potential sources are unlikely to bias our results, for three main reasons. First, for a bias to arise, media attention or social acceptability would have to exogenously trend with the global increase in resource prices *differentially* in resource-rich places.[29] Second, if a change in media attention trending with global price variations in resource-rich areas was the main driver of the results, we would also observe a positive relation between price and sexual violence in cells with industrial mines (resource-rich areas). Our baseline results on sexual violence show that this is not the case. Third, if changes in social acceptability to report sexual violence increased exogenously over time (trending with resource prices), we would also expect a stronger positive relation between agricultural resource areas and sexual violence, as places that are suitable for agriculture are more populated. Lastly, we note that if these biases were driving our results, we would not expect to find a relation between resource prices and other non-lethal forms of violence (non-sexual), as these other forms of violence do not suffer from the same stigma in reporting or sensationalist media coverage. To investigate if this is the case, the remainder of this section focuses on the drivers of the non-sexual forms of violence against civilians.

To assess the relation between non-sexual forms of violence against civilians and resource prices, we reestimate Equation 10 but consider two alternative explained variables. Y_{ict} is now a dummy variable that equals 1 if lethal (non-lethal) events of violence, perpetrated by armed groups against civilians, took place in cell i, in country c, and in year t. Building on the theoretical framework presented in Section 3, if armed groups use violence as a taxation strategy, we would expect that: (i) non-lethal violence is stronger when the value of artisanal mines increases than when the value of agricultural crops increases, because non-lethal violence is used around concealable, labor-intensive resources; (ii) lethal violence is stronger when the value of industrial mines increases than when the value of either artisanal mines or agriculrural crops increases, because lethal violence is used around capital-intensive resources. Furthermore, when considering within resource, we expect that: (i) artisanal mines, which are labor-intensive resources, are more likely to be associated with non-lethal violence than lethal violence – although, as shown in Appendix 8.1, if the armed group's labor is as productive as civilian labor, lethal violence actually dominates non-lethal violence, also around labor-intensive resources; (ii) industrial mines, which are capital-intensive resources, are more likely to be associated with lethal violence than non-lethal violence; (iii) agricultural crops, which are labor-intensive and non-concealable resources, are neither associated with non-lethal nor with lethal violence, but are more prone to non-violence.

Table 3 displays the results for this broader typology of violence. We first focus on non-lethal violence. Column 1 replicates Column 4 of Table 2 for sexual violence as a reference. Column 2 documents that the relation between resource prices and other forms of non-lethal violence perpetrated by armed groups against civilians (excluding sexual violence) follows a similar pattern. Column 3 confirms these results when looking at all non-lethal events together (including sexual violence). As expected, we observe a strong positive effect of an artisanal price shock through all three columns, while the value of industrial mining and agricultural

[29] Any increase in media attention or social acceptability that does not depend on locally available resources is captured in our rich set of fixed effects.

Table 3: Main results: Effect on different forms of violence

	(1)	(2)	(3)	(4)
Dependent variable:	Non-lethal violence			Lethal violence
	Sexual	w/o sexual	All	
Artisanal price shock	0.0055^{a}	0.0063^{a}	0.0079^{a}	0.010^{a}
	(0.001)	(0.002)	(0.002)	(0.004)
Industrial price shock	-0.0049	0.0020	0.00045	0.035^{a}
	(0.003)	(0.008)	(0.007)	(0.010)
Agricultural price shock	0.0025	-0.0049	-0.0017	-0.0045
	(0.002)	(0.004)	(0.004)	(0.007)
Cell × countries FE	Y	Y	Y	Y
Year × ethnic group × countries FE	Y	Y	Y	Y
Observations	273867	273867	273867	273867

LPM estimations. Standard errors in parentheses. ^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01. Conley (1999) standard errors in parentheses, allowing for spatial correlation within a 500 km radius and for infinite serial correlation. The dependent variable is a dummy variable that equals 1 if any event of sexual (Column 1), non-lethal (excluding sexual violence in Column 2, and putting together sexual violence and all other non-lethal violence in Column 3) or lethal (Column 4) violence is observed on that cell-country-year level. A one standard deviation in the price of gold increases sexual violence by two thirds of the sample mean (Column 1), increases non-lethal violence by one fifth of the sample mean (Column 2), and increases lethal violence by one tenth of the sample mean (Column 4).

activities does not display any significant relation to non-lethal violence.

We then turn to lethal violence and observe a different pattern. The rise of resource prices in industrial mining areas significantly increases the use of lethal violence against civilians (Column 4). For artisanal mines, coefficients across types of violence show that when the price of gold increases, lethal as well as non-lethal violence increase. In terms of the model, this result is consistent with armed groups being able to provide some productive labor to extract the resources by themselves.[30] In line with our predictions, we also note that industrial mining has a significantly larger effect on the use of lethal violence than artisanal mining (Column 4).

Within resources, price changes in artisanal mining areas appear to have the strongest impact on the perpetration of sexual violence. These price changes also affect the use of non-lethal violence and, to a lesser extent, the use of lethal violence. To be more precise, a one standard deviation increase in the price of gold increases violence by two thirds of the sample mean if we look at sexual violence (Column 1), a fifth of the sample mean if we look at non-lethal violence (Column 2) and a tenth of the sample mean if we look at lethal violence (Column 4).

Overall, local resources appear to have a similar effect on the incidence of sexual violence and on the incidence of other forms of non-lethal forms of violence. An artisanal price shock significantly increases both forms of violence, albeit sexual violence is the one which reacts most. Aligned with our model, we find that local resources have a different effect on lethal forms of violence, as the industrial price shock becomes the main driver. These results are

[30] $e_A > 0$, as in Extension 8.1), and consistent with some anecdotal evidence. Malango (2016) for example notes, "Likewise, members of armed groups and the national army collaborated with miners, either by working part-time in the mines themselves or by hiring miners to work for them after being allotted their own mining pits."

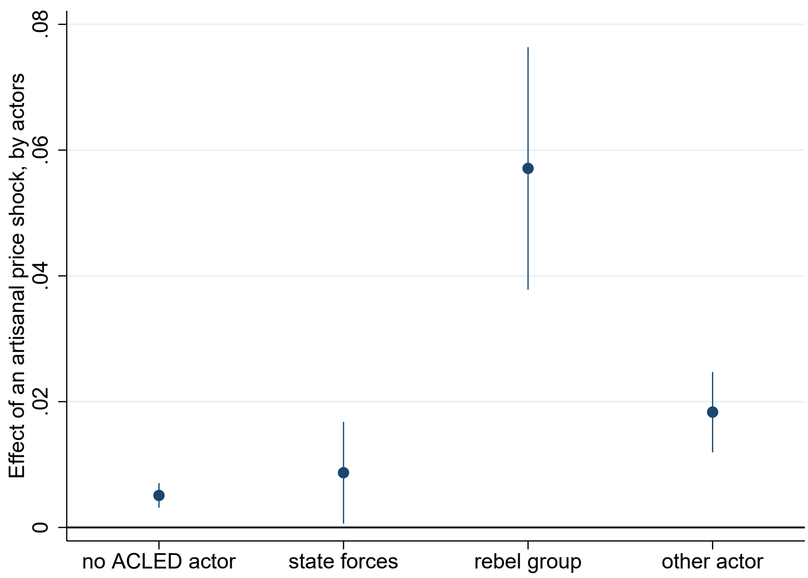
important for two reasons. First, they are consistent with an interpretation of sexual violence as one of the strategic tools armed groups use, among other forms of violence (and non-violence). Second, the differential pattern of results between lethal and non-lethal violence alleviates concerns that our baseline estimates come from a biased measure of sexual violence.

7 The role of the actors and institutional context

We now examine how our baseline results might depend on different group and country characteristics. The existing literature on sexual violence highlights that the characteristics of the actors – perpetrators as well as victims – involved in a conflict are crucial in understanding the use of sexual violence. Our econometric specification accounts for any bilateral relation between local civilian populations and armed groups in an ethnic homeland in a given country and year. In this section, we further document which actors or country characteristics may magnify the relation between sexual violence and a price shock in artisanal mining.

7.1 Characteristics of potential perpetrators

Figure 8: Sexual violence and artisanal price shock, by type of actors present in the cell and year



Note: Each point represents the coefficient of the interaction term between the "Artisanal price shock" variable, and a dummy variable that equals 1 in each cell-year telling of the presence of ACLED actors as listed on the x-axis. The four (non-exclusive) cases of ACLED actors presence tell whether the cell-years has a record of any ACLED event involving state forces, rebel group, other actors, or none of the previous (hence a cell-year without any record of any ACLED event, except potentially an event of sexual violence). We separately control for the dummy variables that are equal to 1 for each of the four cases. The remainder of the specification follows Equation 10. The full results appear in the Column 2 of Table A-11. Bars around each point represent the 90% confidence intervals.

In this subsection, we document how our results are depend of the local presence of violent actors. To do so, we first define a variable, “any ACLED actor”, accounting for any actors involved in an ACLED event *excluding sexual violence* in a specific cell in a given year. We then consider the opposite of this variable, which tells us the cells and years which did not witness any ACLED event. The presence of an active ACLED actor strongly magnifies our coefficient of interest in Column 1 of Table A-11. However, we also document a positive relation between the artisanal price shock and sexual violence in cells that do not have any active actor recorded (albeit about a tenth smaller than the coefficient for cells with an ACLED actor). We see that the presence of such an active actor is significantly positively associated with the incidence of sexual violence in the cell, independent of the presence of resources in the cell.

To test whether sexual violence reacts to actors’ need for funding, we split the “any ACLED actor” variable into three non exclusive subcategories: state forces, rebel groups, and other actors. This split follows the special attention devoted to rebel groups in the literature. Humphreys and Weinstein (2006) highlight that these groups lack the means to police their members’ behavior, which might impact the use of violence against citizens, specifically sexual violence. Following this line of reasoning, we should observe that the presence of a rebel group increases sexual violence, independently of the presence or value of natural resources. Therefore, we document whether the presence of one of these active actors exacerbates the effect of resource prices on sexual violence.

We are particularly interested in what is the effect of the artisanal price shock on sexual violence in cases when a rebel group or state forces are present. While state forces may be present in a zone either to fight rebel groups in that zone or participate in violent events, it is crucial that state forces have in theory no need to tax the local population to sustain their activities. We therefore expect that state forces will not react to resource price shocks as much as rebels do.[31]

The results in Figure 8 imply that rebel groups are the ones who perpetrate more sexual violence during a positive artisanal price shock. Interestingly, we see that these groups do not perpetrate sexual violence significantly more than other groups on average: the main effect of accounting for rebel groups’ presence is insignificant in the Column 2 of Table A-11. In comparison, while state forces’ presence has a positive relation to sexual violence,[32] the state forces react significantly less to the price of gold in artisanal mining areas than rebel groups do. Lastly, we note that the relation between the value of artisanal mines and sexual violence remains significantly positive, even in cell-years without any (recorded) ACLED actor perpetrating another type of ACLED violence.

[31]The last group allows us to be exhaustive and control for other actors recorded in the ACLED whose intention and organization are unclear, namely rioters and protesters, identity and political militias, as well as external and other forces.

[32]We are agnostic on whether this means that state forces do react to an artisanal mining price shock. State forces may be present in a cell for a variety of more or less legitimate reasons, which may include fighting rebel groups, accessing the natural resources, or any other reason consistent with field reports, for example(UN, 2019).

We note that we obtain qualitatively similar results if we allow actors to be mobile within homelands. In Column 4 of Table A-11 , we look at the heterogeneous relation between resources and violence for actors in a given homeland and year. As soon as a actor has been active in a cell-year, we consider that this group was potentially present that year in every cell of the homeland to which that cell belongs.[33] This approach confirms that rebel groups are those who react most to artisanal price shocks. The relationship between the gold price and sexual violence is strongest in the ethnic homeland and years with active rebel groups (Column 4).

Overall, the results in Figure 8 and Table A-11 are consistent with different actors reacting strategically to the presence of local resources. Rebel groups in particular – who are more likely than state forces to need to rely on taxing local resources to sustain their activities – are the ones that increase most their use of sexual violence around artisanal mines when the price of gold increases.

7.2 Civilians' ancestral ethnic characteristics

We now turn to whether local ancestral gender norms might be linked to the perpetration of sexual violence. In a novel analysis, Guarnieri and Tur-Prats (2020) argue that these gender norms have persisted over time, that gender-unequal armed groups are more likely to perpetrate sexual violence, and that the risk of sexual violence increases with the disparity in gender norms between the armed group and the local population. We present results for five ethnic traits related to gender norms as recorded in the Murdock Atlas – a subset of those in Alesina et al. (2020) and Guarnieri and Tur-Prats (2020).

We first investigate the historical main income sources of the local population, as historical economic specialization has been argued to lead to gendered occupations and therefore different gender norms (Alesina et al., 2011). Summarizing extensive literature on the topic, Guarnieri and Tur-Prats (2020) argue that agriculture as the main income source is related to more gender-equal norms than pastoralism or gatherer societies. Table 4 highlights that the effect of an artisanal price shock on sexual violence is magnified in places where the historical income source is associated with more gender-equal norms. The association between sexual violence and local resources is strongest if the local civilians' ancestral ethnic source of income is agriculture, or anything other than pastoralist or gatherer. For a given average level of armed groups' gender norms (usually considered as gender unequal Nagel, 2019; Wood, 2006, 2014), more equal gender norms among the local civilian population therefore amplify our results, consistent with the findings in (Guarnieri and Tur-Prats, 2020).

We then consider ancestral ethnic traits that are more directly linked to the family structure:

[33]This strategy is noisier than when we account for actors that we know have been present in a given cell and year, as we do in Columns 1 and 2. However, the strategy allows us to check for the spatial movements of different actors across each homeland's cells. By construction, the main effect of actors' presence is then absorbed by our fixed effects.

the STEM family structure (which is associated with more gender equality Guarnieri and Tur-Prats, 2020), and polygamy (although there is an ambiguity towards how polygamy relates to gender norms and attitudes toward sexual violence today, Alesina et al., 2020, we here code it as a possible marker of gender inequality). The results are less clearcut than for the gender norms linked to the ancestral income source. The relation between an artisanal price shock and sexual violence is absent in homelands with historical STEM family structures (those that are supposed to be more gender-equal), and present in homelands without the STEM structure. The relation between the artisanal price and sexual violence appears in homelands with as well as without polygamy, and the effects are not statistically different.

Overall, the results in Table 4 indicate that the relation between artisanal mining value and sexual violence is magnified in places where the historical main income source led to more gender-equal norms. This is aligned with the claims in Guarnieri and Tur-Prats (2020), as it would increase the distance with the norms of the average armed group. However, the results on ancestral family arrangements are less clearcut.

Table 4: Characteristics of the historical ethnic homeland

	(1)	(2)	(3)	(4)	(5)
Heterogeneity along:	Agriculture	Pastoralist	Gatherer	STEM	Polygamy
Dependent variable: Sexual violence					
Artisanal price shock × gender equal	0.0100^a	0.0085^a	0.0057^a	-0.0045	0.0078^a
	(0.002)	(0.002)	(0.001)	(0.004)	(0.002)
Artisanal price shock × gender unequal	0.00034	-0.00049	0.0019^a	0.0055^a	0.0045^a
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Industrial price shock	-0.0058^c	-0.0054^c	-0.0051^c	-0.0049	-0.0040^c
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
Agricultural price shock	0.0015	0.0018	0.0024	0.0025	0.0023
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Cell × countries FE	Y	Y	Y	Y	Y
Year × ethnic group × countries FE	Y	Y	Y	Y	Y
Observations	273942	273942	273942	273942	258167

LPM estimations. Standard errors in parentheses. ^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01. Conley (1999) standard errors in parentheses, allowing for spatial correlation within a 500 km radius and for infinite serial correlation. The dependent variable is a dummy variable that is equals to 1 if any event of sexual violence is observed on that cell-country-year level. The historical ethnic homeland information comes from the Murdock database.

7.3 Countries' ethnolinguistic fragmentation and institutions

We close by documenting how country characteristics might shape the relation between resource prices and sexual violence.

Given the literature linking countries' ethnolinguistic fragmentation and conflicts, we investigate whether this fragmentation might magnify the effect of resource prices on violence

(Michalopoulos and Papaioannou, 2013 or Rohner et al., 2013). To do so, we split the artisanal price shock variable by whether the country is above or below the sample median in terms of ethnolinguistic polarization (Column 1) or fractionalization (Column 2). The relation between artisanal mining value and sexual violence stems from countries with a high level of either ethnolinguistic polarization or ethnolinguistic fractionalization. These results open avenues for further research on the causes of sexual violence, such as whether sexual violence might be motivated by ethnic cleansing. These results also highlight the complementary nature of the local economic mechanism that we put forward in this study and the well-established importance of ethnolinguistic fragmentation.

Secondly, following our theoretical framework highlighting that we are analyzing weakly institutionalized regions, we explore whether government indicators such as the rule of law and government performance may alter the relation between sexual violence and the value of local economic resources. Government indicators are taken from the QOG database. As expected, we find that the positive link between the value of artisanal mining and sexual violence is significant when a country's rule of law (and its government performance) is low – below the sample's median. The results are reported in Columns 3 and 4 of Table 5.

Table 5: Heterogeneity by country setting

	(1)	(2)	(3)	(4)
Heterogeneity along:	Ethnic pol.	Ethnic fract.	Rule of law	Gvt perf.
Dependent variable: Sexual violence				
Artisanal price shock × high index	0.0087[a]	0.0080[a]	0.00061	0.00052
	(0.002)	(0.002)	(0.001)	(0.001)
Artisanal price shock × low index	0.0011	0.0012	0.011[a]	0.0093[a]
	(0.001)	(0.001)	(0.002)	(0.002)
Industrial price shock	-0.0051[c]	-0.0047	-0.0046	-0.0042
	(0.003)	(0.003)	(0.003)	(0.003)
Agricultural price shock	0.0027	0.0019	0.0019	0.0022
	(0.002)	(0.002)	(0.002)	(0.002)
Cell × countries FE	Y	Y	Y	Y
Year × ethnic group × countries FE	Y	Y	Y	Y
Observations	259378	259378	265934	265736

LPM estimations. Standard errors in parentheses. [c] p<0.1, [b] p<0.05, [a] p<0.01. Conley (1999) standard errors in parentheses, allowing for spatial correlation within a 500 km radius and for infinite serial correlation. The dependent variable is a dummy equal to 1 if any event of sexual violence is observed on that cell-country-year level. Ethnic polarization and fragmentation are taken from the Reynal-Querol database. Indexes for the rule of law and government performance come from the QOG database. Rule of law is the variable wbg_rle with a higher value indicating higher enforcement of the rule of law. It accounts for perceptions of the incidence of crime, the effectiveness and predictability of the judiciary, and the enforceability of contracts. Government performance is the variable bti_pdi from 1 to 10, with 10 indicating higher performance of democratic institutions.

8 Conclusion

This study provides a systematic analysis of the impact of local economic resources on the strategic use of sexual violence by armed groups throughout Africa. Our theoretical analysis highlights that sexual violence – a form of non-lethal violence that armed groups may use to increase illegal taxation on civilians – is more likely to arise if the value of a local resource that is labor-intensive and easy to hide increases. Our empirical analysis investigates the exogenous time variation in commodity prices in a fine-grained panel of cells covering the African continent, and yields results aligned with our theoretical predictions. The value of artisanal gold mining, which is labor-intensive and easy to hide, has a statistically significant and quantitatively large impact on the likelihood that armed groups may resort to sexual violence.

According to our estimates, a one standard deviation increase in the price of gold increases the incidence of sexual violence in cells that may host artisanal mines by two thirds of the full sample mean incidence of sexual violence. This finding remains true if we account for battle incidence or the presence of violent forces in the cell. We also show that the relation between sexual violence and the value of artisanal mining is magnified when armed groups are more likely to be dependent on local resource taxation, as well as in countries with a high level of ethnolinguistic fragmentation or a low level of the rule of law.

To alleviate concerns that our baseline results stem from a media or reporting bias around sexual violence, we generalize our findings to a broader typology of violence. In particular, we document a qualitatively similar positive relationship between artisanal mining value and other forms of non-lethal violence against citizens. In addition, we find a weak and negative impact for the value of industrial mining – an easily concealable but capital-intensive resource – and no impact for the value of agricultural activities – which are labor-intensive but harder to hide. In contrast, a rise in the value of industrial mines increases the use of lethal violence. These findings are important because they provide additional evidence that is consistent with the notion that armed groups strategically perpetuate violence against civilians based on the value of the resources to be taxed.

To the best of our knowledge, this study highlights a short-term economic motivation behind the use of sexual violence by armed groups for the first time. We believe that this contribution is important from an academic as well as a policy perspective. In terms of policy implications, our results are consistent with strategic decision-making that depends on local economic resources. We highlight that zones with artisanal mining activities are associated with particularly high risks when the price of gold increases. Taking this into account, we believe that sexual violence may be (in part) avoidable.

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8.1 Theoretical proofs and extensions

Proof of result on lethal violence (equation 9). The armed group considers three possible states of violence and their associated tax levels: $\{\texttt{non\_violence}; \texttt{non\_lethal}; \texttt{lethal}\}$. However, `lethal` is not dominated anymore, as in the capital-intensive case $\pi_{\texttt{A}} = \pi_{\texttt{C}} = R \times p$. Following the same reasoning as above, the armed group is better off exerting `non_lethal` violence than non-violence if

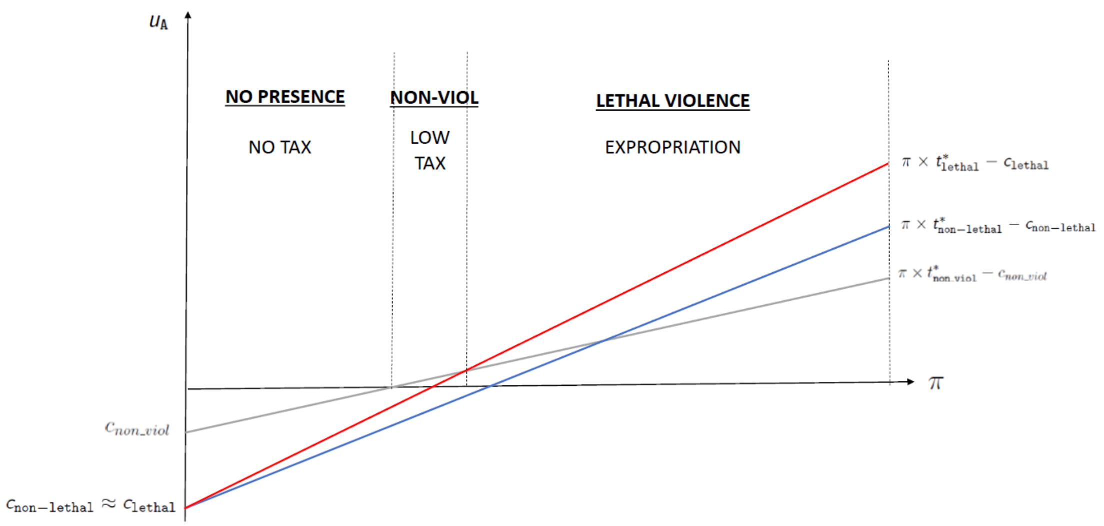
$$p > \frac{c_{\texttt{non\_lethal}} - c_{\texttt{non\_viol}}}{R(1-\delta_{\nu})(q_{\texttt{non\_viol}} - q_{\texttt{non\_lethal}})} \tag{11}$$

and is better off exerting `lethal` rather than `non_lethal` violence if

$$p > \frac{c_{\texttt{lethal}} - c_{\texttt{non\_lethal}}}{R(1-\delta_{\nu})(q_{\texttt{non\_lethal}})} \tag{12}$$

Consequently, assuming $c_{\texttt{lethal}} \approx c_{\texttt{non\_lethal}}$, `non_lethal` violence is dominated by `lethal` violence. This implies that we should observe only lethal violence around capital-intensive resources.[34] Figure A-1 summarizes the armed group payoff for various levels of profitability of the capital-intensive resource.

Figure A-1: State of violence – capital-intensive resource, no productive labor of the armed group



Armed group provides effective labor units ($e_A > 0$). Here we relax the assumption that fighters are unable to provide productive labor. We specifically assume that $e_A = \beta e$, with $0 \leq \beta \leq 1$. This implies that `lethal` is not necessarily dominated anymore, as $\pi_{\texttt{A},\alpha=1} = p^2(\beta - \frac{\beta^2}{2}) > 0$. The armed group is therefore better off exerting `lethal` than `non_lethal` violence if $\pi_{\texttt{A}} - c_{\texttt{lethal}} > \pi \times t^*_{\texttt{non\_lethal}} - c_{\texttt{non\_lethal}}$. Therefore, if

$$p^2 \left(2\beta - \beta^2 - 1 + q_{non\_lethal}(1-\delta_{\nu})\right) > 2(c_{\texttt{lethal}} - c_{\texttt{non\_lethal}}) \tag{13}$$

Assuming, as in the baseline, $c_{\texttt{lethal}} \approx c_{\texttt{non\_lethal}}$ condition 14 becomes

[34] We rely on this simplifying assumption to ease the exposition of the results. It is however easy to check that if $c_{\texttt{lethal}} > c_{\texttt{non\_lethal}}$, it will just add the possibility of observing non-lethal violence around capital-intensive resources for a "medium" price level. In particular, we will observe a "non-lethal" zone of violence if $\frac{c_{\texttt{lethal}} - c_{\texttt{non\_viol}}}{c_{\texttt{non\_lethal}} - c_{\texttt{non\_viol}}} < \frac{q_{\texttt{non\_viol}}}{q_{\texttt{non\_viol}} - q_{\texttt{non\_lethal}}}$

$$2\beta - \beta^2 + q_{non\_lethal}(1 - \delta_\nu) > 1 \tag{14}$$

Therefore, if fighters have very low productivity (or can provide only limited labor units), β is low and `lethal` is dominated (as $q_{non\_lethal}(1 - \delta_\nu) < 1$). We therefore observe a shift from non-violence to non-lethal violence if condition 7 is met. If β is high enough, condition 14 is satisfied and `lethal` violence replaces non-violence if

$$p > \sqrt{\frac{2(c_{\texttt{lethal}} - c_{\texttt{non\_viol}})}{\left(\beta - \frac{\beta^2}{2} - 1 + (1 - \delta_\nu)(q_{\texttt{non\_viol}})\right)}} \tag{15}$$

An armed group is therefore more likely to exert lethal violence around a labor-intensive resource if its fighters are able to provide productive labor. The higher fighters' productivity, the lower the right-hand side of condition 15 and the easier it is for non-violence to turn into lethal violence.

Decision with a constrained group of fighters. In the main part of the theory, we assume that the pool of fighters $\overline{F}$ from which the armed group is recruiting is large, in the sense that the armed group has access to enough fighters to implement its optimal strategy in the different villages of the region where it operates.

The optimal aggregated allocation maximizing equation (1) is therefore the simple sum of the armed group's optimal local decisions. In practice, the pool of fighters may also be constrained over the short/medium term, for example if the fighters' labor supply is inelastic, or because it takes time to recruit and train fighters. In this constrained case, the number of available fighters $\overline{F}$ might not be high enough for the armed group to implement its optimal decision in each village. We denote by F^* the number of fighters maximizing equation (1). If $F^* > \overline{F}$, even if the potential surplus of a higher state of violence would be positive in all villages if the armed group was in the unconstrained case, the group has to allocate the fighters in priority to the villages that bring the highest surplus and eventually diminish the number of fighters in villages that bring a lower surplus.

In this situation, a resource price increase will lead to higher levels of violence in a village rich in this resource if and only if the increase in surplus in this village is higher than the loss in surplus the group will incur in other villages by reallocating fighters across the villages. The constraint on the pool of fighters basically increases the "opportunity cost" of violence for the armed group. This constraint tampers the overall use of violence, as increased violence in a village is associated with decreased violence in other villages in the region.

Empirically, being in this constrained case may have three types of consequences. If the reallocation of fighters takes place within cells (which are 0.5×0.5 degrees), our estimates pick up an average effect that will be downward-biased compared to the unconstrained case. If the reallocation happens between neighboring cells, we will only observe violence in the cells that provide the highest surplus, and reduced or even no violence in other cells. If there is a correlation between prices in the cell and violence in the neighboring cells (for example if the type of resource in a cell is correlated across neighboring cells) we will observe an increase in sexual violence only in some of the cells with resources after a price increase (not all of them), attenuating our coefficient of interest. Alternatively, if there is no correlation between resource prices in a cell and the occurrence of violence in neighboring cells (for example because there is no correlation of resource prices across these cells) a constraint on the size of the pool of fighters will simply translate into a spatial correlation in residuals of our estimates. In all our estimations, we account for this possibility of spatial correlation in the structure of our standard errors.

8.2 Trust and violence

This subsection investigates the correlation between sexual violence and trust, in support of the interpretation that sexual violence can be used to annihilate local populations. The matter of the consequences of sexual violence on the social fabric is a key research question that deserves a separate study. This section provides a first rapid overview of the qualitative evidence in the literature and empirical correlations.

There is substantial qualitative evidence that sexual violence has devastating consequences on individual, community, and societal levels. Section 2 highlights the contemporaneous effects of sexual violence in terms of trauma, and we quote a few references about the link between sexual violence and the social fabric here. For instance, Major-General Patrick Cammaert, former commander of UN peacekeeping forces in the eastern part of the DRC, reports to UNHCR that "[w]arring groups use rape as a weapon because it destroys communities totally."[35] Amnesty International further reports that "whether a woman is raped at gunpoint or trafficked into sexual slavery by an occupying force, the sexual abuse will shape not just her own but her community's future for years to come."[36] The Mukwegue Foundation, devoted to supporting female victims of sexual violence in the DRC, also reports that "[t]he consequences go far beyond individual suffering. Sexual violence committed across entire communities spreads diseases, destroys family ties and inflicts harm over generations."[37], and that "[c]onflict-related sexual violence is also a security threat that destabilises countries for generations."[38]

In addition, we document the correlation between the level of trust and the incidence of violent events to assess if the legacy of sexual violence differs from that of other forms of violence. To this end, we consider the level of trust respondents reported to the Afrobarometer survey waves 3 to 6. We know which respondent lives in a cell that has been exposed to sexual violence or other forms of violence thanks to the geolocalization of the respondents. We use general trust as a dependent variable, which is a dummy that equals 1 if the respondent is generally trusting and 0 otherwise. We also generate a trust gap that captures the difference between the dummy variables of general trust and trust towards relatives. We can interpret this variable, as the higher its value is, the higher the trust toward a respondent's outgroup.

We estimate the following equation:

$$Y_{ivct} = \alpha_1 + \alpha_2 violence_{ct} + \alpha_3 \alpha_4' X_{it} + FE_{country \times years} + FE_t + \varepsilon_{ict},$$

Where Y_{ict} indicates the trust level of individual respondent i, in village v, in cell c c, and year t. As we are interested in the correlation between this level of trust and the incidence of violent events, our right-hand side variable of interest is $violence_{ct}$, a dummy variable that equals 1 if the cell in which the respondent lives has witnessed an incidence of violence in the survey year. We consider different forms of violence: sexual violence, non-lethal violence against civilians (excluding sexual violence), lethal violence against civilians, battles between armed groups and all ACLED events (excluding events of sexual violence). X_{it} is a set of individual controls, including a dummy that equals 1 if the respondent resides in the homeland of their

[35] https://www.ohchr.org/EN/NewsEvents/Pages/RapeWeaponWar.aspx
[36] http://news.bbc.co.uk/2/hi/4078677.stm
[37] https://www.mukwegefoundation.org/the-problem/rape-as-a-weapon-of-war/
[38] https://www.mukwegefoundation.org/the-problem/consequences-sexual-violence-conflict/

ethnic group, a control for urban areas, as well as the respondent's gender, age, age squared, education level, and employment status. We also include a set of fixed effects to account for time-varying changes in the level of trust at the country level.

Tables A-1 and A-2 show how different forms of violence relate to respondents' general trust levels and the trust gap respectively. We first look for the correlation of general trust and trust gap for different types of violence (Columns 1 to 5), then we account for all types of violence simultaneously (Column 6). We first consider only violence that takes place at the time of the survey. The last column of each table then investigates persistence by looking at the incidence of sexual violence in the five years prior to the survey, through a dummy variable that equals 1 if any event of violence, as defined by the variable name, took place in the cell in the five years prior to the survey.

All forms of violence are negatively associated with trust; however, we see that the magnitude and precision of the coefficient are considerably more important for sexual violence. Sexual violence reduces both general trust, or the trust gap, which particularly reduces trust towards one's outgroup. Aligned with the qualitative evidence above, we also see that the relation between sexual violence and trust persists over time (Column 7 of Tables A-1 and A-2).

Table A-1: General trust and violence.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Violence contemporaneous to the survey moment						Past 5 years
Dependent variable: General trust							
Sexual violence	-0.051^{b}					-0.042^{c}	-0.024^{c}
	(0.022)					(0.022)	(0.012)
Non-lethal violence (excl. sexual)		-0.016				0.0024	-0.0050
		(0.012)				(0.012)	(0.010)
Lethal violence			-0.017^{b}			-0.014	-0.014
			(0.007)			(0.010)	(0.009)
Battle				-0.015^{c}		-0.0075	-0.0056
				(0.009)		(0.010)	(0.009)
Any ACLED event (excl. sexual)					-0.010^{c}	0.00012	0.0023
					(0.006)	(0.009)	(0.008)
Year × countries FE	Y	Y	Y	Y	Y	Y	Y
Observations	66134	66134	66134	66134	66134	66134	66134

LPM estimations. Standard errors in parentheses. ^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01. Standard errors in parentheses clustered by country cells. Every regression includes the following individual controls: dummy for residing in the EPR homeland, and urban area, gender, age, age squared, education level, and employment status.

Table A-2: Trust gap and violence.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Violence contemporaneous to the survey moment						Past 5 years
Dependent variable: Trust gap							
Sexual violence	-0.102[a]					-0.0779[b]	-0.0703[a]
	(0.031)					(0.032)	(0.020)
Non-lethal violence (excl. sexual)		-0.0439[b]				-0.0286	-0.00710
		(0.018)				(0.020)	(0.015)
Lethal violence			-0.00864			0.00138	-0.00455
			(0.013)			(0.016)	(0.013)
Battle				-0.0250[b]		-0.0180	-0.0163
				(0.013)		(0.016)	(0.013)
Any ACLED event (excl. sexual)					-0.00448	0.00809	0.0276[b]
					(0.009)	(0.013)	(0.012)
Year × countries FE	Y	Y	Y	Y	Y	Y	Y
Observations	62323	62323	62323	62323	62323	62323	62323

LPM estimations. Standard errors in parentheses. [c] $p<0.1$, [b] $p<0.05$, [a] $p<0.01$. Standard errors in parentheses clustered by country cells. Every regression includes the following individual controls: dummy for residing in the EPR homeland, and urban area, gender, age, age squared, education level, and employment status.

8.3 Artisanal mining activities and socio-economic outcomes

The artisanal mining proxy we use has the interest of being exogenous to local factors. As a result, one may however be concerned that it is too noisy to impact socio-economic outcomes. To alleviate this concern, Girard and Vic (2020) proceed to different tests. We display a summary of their results below. We focus this summary on results for artisanal mines whose presence is defined at the cell level, as this is the level we use in the paper.

First, Girard and Vic (2020) report that the likelihood that respondents to the Demographic Health Surveys work in the extractive sector increases with the artisanal mining proxy. This increase is precise only for respondents' sector of activity and imprecise for their partners (Columns 1 and 2 of Table A-3). Second, the asset index of these respondents reacts positively to artisanal mining (Column 3 of Table A-3). For these two sets of results, we note that the cell level of analysis yields less precise estimates than the household level of analysis displayed in Girard and Vic (2020) (the later analysis rests on buffers around the DHS clusters of where the households live to define treated households, as in Bazillier and Girard, 2020). We also note that coefficients are positive and of comparable magnitude. Lastly, Girard and Vic (2020) show that nightlight emissions, a standard proxy of local economic activities that provide a yearly coverage of the entire continent over the 1998-2012 period, also react positively to the artisanal mining proxy (Column 4 of Table A-3).

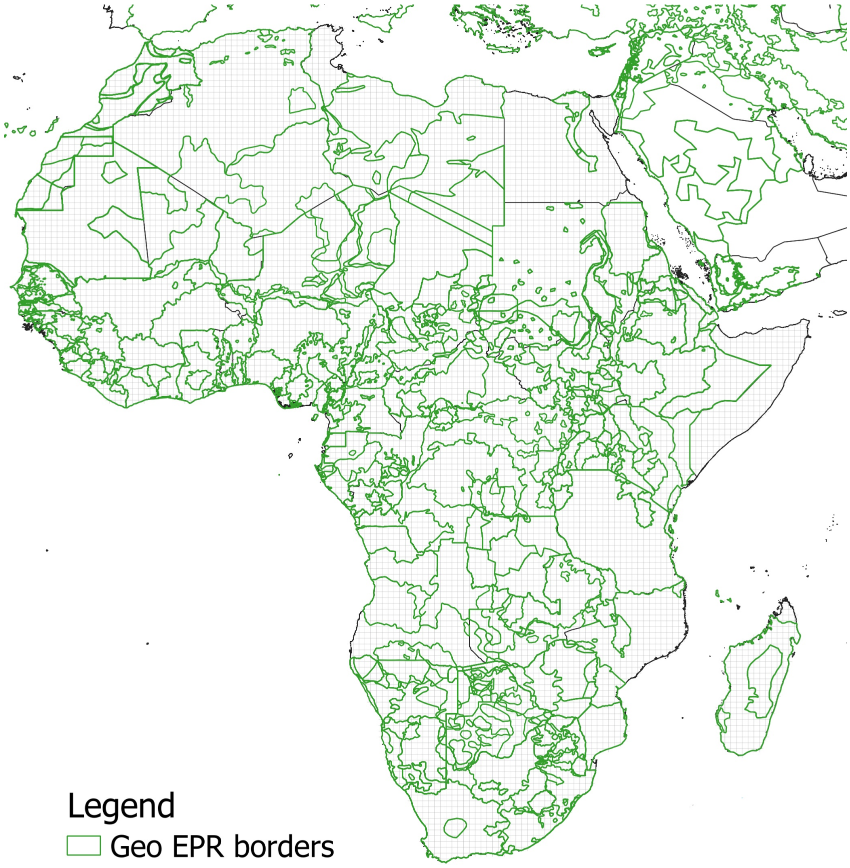
Table A-3: Artisanal mines and extractive sector activity, household wealth, or nightlight emissions.

	(1)	(2)	(3)	(4)
Dependent variable:	Respondent in extractive	Partner in extractive	Wealth factor	Nightlights
Artisanal price shock	0.0062^{c}	0.0066	0.058^{c}	0.00097^{a}
	(0.003)	(0.006)	(0.030)	(0.0002)
Cell × countries FE	Y	Y	Y	Y
Year × countries FE	Y	Y	Y	Y
Controls	Y	Y	Y	N
Observations	378433	381941	544008	170605

Source: Girard and Vic (2020) LPM estimations. ^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01. Standard errors in parentheses clustered by cells. The coefficients for Columns 1 to 3 are estimated from the following equation: $Y_{ivct} = \alpha \text{Artisanal price shock}_{ct} + \beta_4' X_{it} + FE_{country \times t} + FE_{country \times c} + FE_t + \varepsilon_{ict}$, Where Y_{ict} indicates the outcome variable of interest for individual respondent i (be it the woman surveyed or her partner), in village v, in cell c c, and year t. Controls include respondent age, a dummy for residence in rural area, respondent's education (9 categories), and month of interview. The data comes from 77 DHS rounds from 25 countries of Sub-Saharan Africa since 1992. The coefficient for Column 4 comes from the following equation: $Y_{ct} = \alpha \text{Artisanal price shock}_{ct} + FE_{country \times t} + FE_{country \times c} + FE_t + \varepsilon_{ct}$, Where Y_{ct} indicates the average (calibrated) nightlight emissions in cell c c, and year t. The nightlight emissions in the cell are captured by satellites, the original image and data processing was by NOAA's National Geophysical Data Center. DMSP data collected by US Air Force Weather Agency.

8.4 Appendix figures

Figure A-2: EPR homeland borders



Source: Geo EPR. The figure overlays the 2013 and 2019 homeland definitions.

8.5 Appendix tables

Table A-4: Repartition of ACLED events involving armed groups and civilians, by subevent type

Subevent type	Events incidence in the ACLED	Share of events with (at least one) fatality recorded
Abduction/forced disappearance	5,026	0
Air/drone strike	1,718	51.46
Arrest	731	0.14
Attack	49,730	58.9
Chemical weapon	26	30.37
Grenade	1,333	36.76
Looting/property destruction	2,159	2.78
Other	312	6.41
Remote explosive/landmine/IED	2,871	53.78
Sexual violence	2,204	23.37
Shelling/artillery/missile attack	926	53.46
Suicide bomb	687	1
Total	67,723	50.09

Table A-5: Repartition of the main minerals being produced by industrial mines, by cell

Main mineral produced	Number of cells	Share of cells
Aluminum	88	1.38
Coal	770	12.07
Copper	814	12.76
Diamond	1,078	16.9
Gold	2,288	35.86
Iron	352	5.52
Lead	88	1.38
Nickel	132	2.07
Phosphate	198	3.1
Platinum	220	3.45
Silver	22	0.34
Tantalum	44	0.69
Tin	66	1.03
Zinc	220	3.45

Table A-6: Estimates of individuals related to ASM in some Sub-Saharan African countries

Main minerals extracted		Workers		Dependent	
in artisanal mines	Country	Number	Share	Number	Share
Gold alone	Burkina Faso	200,000		1,000,000	
	Chad	100,000		600,000	
	Eritrea	400,000		2,400,000	
	Ethiopia	500,000		3,000,000	
	Mali	400,000		2,400,000	
	Niger	450,000		2,700,000	
	Nigeria	500,000		2,500,000	
	South Africa	20,000		na	
	South Sudan	200,000		1,200,000	
	Tanzania	1,500,000		9,000,000	
	Uganda	150,000		900,000	
	Total gold alone	*4,420,000*	54%	*25,700,000*	56%
Gold and others	Central African Republic	400,000		2,400,000	
	Cote d'Ivoire	100,000		600,000	
	Ghana	1,100,000		4,400,000	
	Guinea	300,000		1,500,000	
	Liberia	100,000		600,000	
	Sierra Leone	300,000		1,800,000	
	Zimbabwe	500,000		3,000,000	
	Total gold and others	*2,800,000*	34%	*14,300,000*	31%
Others and gold	DRC	200,000		1,200,000	
	Madagascar	500,000		2,500,000	
	Malawi	40,000		na	
	Mozambique	100,000		1,200,000	
	Total others and gold	*840,000*	10%	*4,900,000*	11%
Diamonds alone	*Angola*	*150,000*	2%	*900,000*	2%
All		8,210,000	100%	45,800,000	100%

Source: Hilson (2016).

Table A-7: Crops most suitable for cultivation

Crop	Number of cells	Percentage
Sorghum	1,155	23.58
Pearl millet	795	16.23
Dryland rice	645	13.17
Pigeon pea	621	12.68
Coffee	316	6.45
Maize	187	3.82
Yams	171	3.49
Sunflower	156	3.18
Palm oil	154	3.14
Coconut	116	2.37
Cowpea	108	2.2
Wheat	97	1.98
Barley	85	1.74
Green gram	77	1.57
Alfalfa	59	1.2
Cacao	58	1.18
Banana	31	0.63
Cotton	21	0.43
Sweet potato	21	0.43
Tomato	12	0.24
Rice	7	0.14
Buckwheat	5	0.1
Reed canary grass	1	0.02
White potato	1	0.02
Total	4,899	100

Table A-8: Varying controls

	(1)	(2)	(3)	(4)
Dependent variable: Sexual violence				
Artisanal price shock	0.0058[a]	0.0058[a]	0.0054[a]	0.0059[a]
	(0.001)	(0.001)	(0.001)	(0.001)
Industrial price shock	-0.0056[c]	-0.0057[c]	-0.0056[c]	-0.0064[b]
	(0.003)	(0.003)	(0.003)	(0.003)
Agricultural price shock	0.0029	0.0022	0.00063	0.00085
	(0.002)	(0.002)	(0.002)	(0.002)
Population density	0.00014[a]			0.00014[a]
	(0.000)			(0.000)
Gross cell product		0.0092[a]		0.0012
		(0.003)		(0.003)
Forest cover			-0.055	0.00020
			(0.046)	(0.047)
Water cover			10.6	14.2
			(23.120)	(23.745)
Barren land			-0.25[c]	-0.13
			(0.136)	(0.137)
Grass cover			0.014	0.012
			(0.019)	(0.019)
Savanna cover			-0.14[a]	-0.13[b]
			(0.051)	(0.052)
Cell × countries FE	Y	Y	Y	Y
Year × ethnic group × countries FE	Y	Y	Y	Y
Observations	273867	267399	269652	263470

LPM estimations. Standard errors in parentheses. [c] p<0.1, [b] p<0.05, [a] p<0.01. Conley (1999) standard errors in parentheses allowing for spatial correlation within a 500 km radius and for infinite serial correlation. The dependent variable is a dummy variable that equals 1 if any event of sexual violence is observed in that cell-country-year level.

Table A-9: Alternative resource variables

	(1)	(2)	(3)	(4)
Resource focus	Gold mines		Main crop cultivated	
Dependent variable: Sexual violence				
Artisanal price shock		0.0055^{a}		0.0055^{a}
		(0.001)		(0.001)
Industrial price shock – gold	-0.0077	-0.0096^{c}		
	(0.005)	(0.005)		
Industrial price shock – no gold	-0.00026	-0.0014		
	(0.003)	(0.003)		
Industrial price shock				-0.0050^{c}
				(0.003)
Agricultural price shock		0.0024		
		(0.002)		
Crop price shock			0.0043^{c}	0.0043^{c}
			(0.002)	(0.002)
Cell × countries FE	Y	Y	Y	Y
Year × ethnic group × countries FE	Y	Y	Y	Y
Observations	273867	273867	273867	273867

LPM estimations. Standard errors in parentheses. ^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01. Conley (1999) standard errors in parentheses allowing for spatial correlation within a 500 km radius and for infinite serial correlation. The dependent variable is a dummy variable that equals 1 if any event of sexual violence is observed in that cell-country-year level.

Table A-10: Alternative specifications

	(1)	(2)	(3)	(4)	(5)
Variation	Fixed effects		omit split cells	omit DRC	Intensive margin
Dependent variable: Sexual violence					
Artisanal price shock	0.0055^{a}	0.0056^{a}	0.0057^{a}	0.0034^{a}	0.027^{a}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.008)
Industrial price shock	-0.0049	-0.0050^{c}	-0.0063^{c}	-0.0048	-0.012b
	(0.003)	(0.003)	(0.004)	(0.003)	(0.005)
Agricultural price shock	0.0025	0.0019	0.0039^{c}	0.0041^{b}	-0.0038
	(0.002)	(0.002)	(0.002)	(0.002)	(0.010)
Cell × countries FE	Y	Y	Y	Y	Y
Year × Mira group × countries FE	Y	N	N	N	N
Year × countries FE	N	Y	N	N	N
Year × ethnic group × countries FE	N	N	Y	Y	Y
Observations	273942	273942	226122	255330	273942

LPM estimations. Standard errors in parentheses. ^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01. Conley (1999) standard errors in parentheses allowing for spatial correlation within a 500 km radius and for infinite serial correlation. The dependent variable is a dummy variable that equals 1 if any event of sexual violence is observed in that cell-country-year level.

Table A-11: The ACLED actors active around artisanal mines

	(1)	(2)	(3)	(4)
	Actors in the cell-year		Actors in the homeland-year	
Dependent variable: Sexual violence				
Artisanal price shock × any ACLED actor	0.026[a]		0.0056[a]	
	(0.005)		(0.001)	
Artisanal price shock × rebel forces		0.057[a]		0.0043[a]
		(0.012)		(0.001)
Artisanal price shock × state forces		0.0087[c]		0.00054
		(0.005)		(0.001)
Artisanal price shock × other ACLED actors		0.018[a]		0.0024[a]
		(0.004)		(0.001)
Artisanal price shock × no ACLED actor	0.0020[b]	0.0051[a]	0.0031[c]	0.0022
	(0.001)	(0.001)	(0.002)	(0.002)
Industrial price shock	-0.0082[a]	-0.0088[a]	-0.0049	-0.0048
	(0.003)	(0.003)	(0.003)	(0.003)
Agricultural price shock	0.0019	0.0021	0.0024	0.0023
	(0.002)	(0.002)	(0.002)	(0.002)
Any ACLED actor	0.0051[a]			
	(0.001)			
Rebel forces		-0.0026		
		(0.003)		
State forces		0.011[a]		
		(0.002)		
Other ACLED actors		0.0032[b]		
		(0.001)		
Cell × countries FE	Y	Y	Y	Y
Year × ethnic group × countries FE	Y	Y	Y	Y
Observations	273942	273942	273942	273942

LPM estimations. Standard errors in parentheses. [c] p<0.1, [b] p<0.05, [a] p<0.01. Conley (1999) standard errors in parentheses, allowing for spatial correlation within a 500 km radius and for infinite serial correlation. The dependent variable is a dummy equal to 1 if any event of sexual violence is observed on that cell-country-year level. An "active ACLED actor" is any group involved in an ACLED event *excluding sexual violence* in a cell-country-year.