DIAMONDS: REBEL'S AND FARMER'S BEST FRIEND[1]

Impact of variation in the price of a lootable, labour-intensive natural resource on the intensity of violent conflict

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Abstract

This paper investigates the impact of the world price of a 'lootable', labour-intensive natural resource on intensity of violent conflict. Results suggest that a price increase can have opposite effects at different

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geographical levels of analysis: a decrease in conflict intensity overall in resource-rich countries, but an increase in conflict intensity in resource-rich sub-national regions. The paper argues that intensity of violence decreases overall due to rising opportunity costs of rebellion, but that violence concentrates in resource-rich areas as returns to looting rise. The paper introduces a new measure of diamond propensity based on geological characteristics, which is arguably exogenous to conflict and can capture small-scale labour-intensive production better than existing measures. The stated effects are found for secondary diamonds, which are lootable and related to opportunity costs of fighting, but not for primary diamonds, which are neither.

1. Introduction

"The root of the conflict remains diamonds, diamonds and diamonds" a United Nations representative reputedly said to the Security Council about the civil war in Sierra Leone (Keen 2005). If natural resources are thought to contribute to violent conflict, 'lootable' resources such as gems have earned special culprit status as "rebel's best friend" (Olsson 2006). These lootable resource are thought to provide easy access to finance for rebel movements relative to the government, because they occur spread out across a large stretches of territory, can be extracted through simple methods, and are easily smuggled (Le Billon 2009).

But these resources may also have a different face. Many qualitative studies emphasize that diamonds are a source of livelihoods for artisanal miners and farmers during the agricultural off-season, and as such also "farmer's best friend" (Van Bockstael and Vlassenroot 2012). Although estimates of the number of artisanal diamond miners are rough approximations at best, they are large: 500,000 in Sierra Leone (Maconachie and Binns 2007) over 300,000 in Angola (Dietrich 2000), and 700,000 in the DRC (Smillie 2005). Artisanal diamond mining plausibly has linkages to local agriculture and the service economy (Hilson and Clifford 2010; Maconachie and Binns 2007). Such improved livelihoods are generally considered to lower conflict risk.

This paper investigates lootable, labour-intensive resources, specifically diamonds, and finds that these might be *both* rebel's and farmer's "best friend". These superficially contradictory effects manifest at different geographical levels of analysis. The paper investigates the impact of variation in the world diamond price on the intensity of violent conflict in countries and sub-national areas in Africa over the period Q3 2004 to Q2 2015. Results suggest that an increase in diamond price leads to a *decrease* in the intensity of violence overall in countries geologically likely to possess lootable, labour-intensive diamonds, but to a *concentration* of violence in areas likely to produce them.

Recent works investigating the relationship between natural resources and conflict increasingly exploit variation within countries over time (Smits et al. 2016; Berman et al. 2017; Arezki, Bhattacharyya, and Mamo 2015). This has clear methodological advantages, yet the study of the 'biggest culprit' resources has lagged behind due to a lack of data. Datasets recording the location of mining commonly only include large mining operations (Berman et al. 2017), and small-scale and labour-intensive mining is by nature difficult to capture.

Furthermore, different theoretical mechanisms linking natural resources to conflict may dominate at different geographical levels of analysis. Three theoretical mechanisms have received much attention: (1) natural resource revenue constituting a 'prize' for those who overthrow national government, or who loot from or extort mining companies, miners, or local government; (2) labour-intensive natural resource production raising the opportunity costs of conflict; (3) natural resource revenue increasing government capacity to resist challengers. Although violence related to looting of miners is a local phenomenon, increased government capacity or increased incentives to overthrow government may be felt throughout a country, and so could increasing opportunity costs of conflict if strong spill-overs exist.

This paper contributes to the existing literature in three ways. First, it investigates the relationship between natural resources and conflict at more than one geographical level of analysis and illustrates that different theoretical effects may dominate at different levels. Second, it presents a new measure for the presence of primary and secondary diamonds that is arguably exogenous to conflict and can capture potential for small-scale labour-intensive production better than existing datasets. Third, it investigates the relationship between lootable, labour-intensive resources and conflict using sub-national variation in resource occurrence and variation in international price over time. This has not been previously done for gems, despite their strong anecdotal association with violent conflict.

This paper focuses on diamonds, because they are a microcosm of the three main mechanisms through which natural resources may be connected to violent conflict. There exist two types of diamonds, primary and secondary diamonds, which are chemically identical yet differ in their labour-intensiveness, 'lootability', and potential for government revenue. Primary diamonds are embedded in their host rock, and excavating them is a capital-intensive process. Deposits of host rocks are typically less than a kilometre in diameter and easily defended against looting by companies or governments. Finally, governments of primary diamond producing countries typically capture between 10% and 75% of the value of production (Oomes and Vocke 2003). As such, primary diamonds could theoretically be related to conflict by raising the 'prize' of overthrowing government or by strengthening government capacity. Secondary diamonds by contrast, are eroded away from the host rock by rivers or the sea and can be extracted by digging and sorting gravel, a labour-intensive process. Secondary diamond fields can stretch out for tens of thousands of square kilometres (Sutherland 1982), and diamonds' high value-to-weight ratio makes them easy to smuggle. These characteristics make them 'lootable', or more likely to provide revenue to rebel movements than to the government (Le Billon 2009). There are extensive reports of rebel movements engaging in secondary diamond mining and smuggling (Le Billon 2009; Keen 2005), whereas government revenue from secondary diamonds ranges only between 0.8 and 3.7% of production value (Oomes and Vocke 2003). Therefore, secondary could theoretically be related to conflict by raising the returns to looting or by increasing the opportunity costs of conflict.

This paper outlines the intuition behind a simple theoretical model of lootable, labour-intensive resources and the intensity of violent conflict. This model predicts that an increase in the price of a lootable, labour-intensive natural resource may have different effects at different geographical levels of analysis: a decrease in violence at the country level due to an opportunity cost effect, but a concentration of violence in regions producing this resource as returns to looting rise. This model is consistent with four otherwise puzzling facts about the conflict in Sierra Leone.

Then, the paper introduces a new measure for the presence of primary and secondary diamonds, diamond propensity, which can capture small-scale labour-intensive diamond production arguably better than existing datasets. Diamond propensity is an estimate of how suitable an area is for diamonds, based on its geological characteristics, which are arguably exogenous to violent conflict.

Using this measure, results suggest that an increase in the international diamond price leads to a decrease in intensity of violence in countries geologically likely to have secondary diamonds, but to an increase in intensity of violence in sub-national areas (grid-cells) where these are likely located. This is in accordance with the theoretical model presented. This effect is economically significant. A back-of-the-envelope difference-in-difference calculation suggests that a one standard deviation increase in the world diamond price is related to 1832 *fewer* fatalities per quarter in all African countries with above-mean secondary diamond propensity combined, but to a combined *increase* in intensity of violence by 36 fatalities per quarter in grid-cells with secondary diamond propensity relative to country trends. Similar results are not found for primary diamonds.

Results furthermore suggest that an increase in the diamond price is related to increased economic activity, proxied by the amount of light emitted at night, in grid-cells likely to produce secondary diamonds. Moreover, increases in economic activity, but not increases in intensity of violence, spill over to adjacent grid-cells. Various robustness checks are presented relating to the potential endogeneity of the diamond price to conflict, the validity of the diamond propensity measures, sensitivity to including a variety of control variables, and to employing different econometric specifications.

The remainder of this paper is organized as follows. Section 2 presents existing empirical evidence and theoretical models. Section 3 presents a simple theoretical model. Section 4 considers case-study evidence. Section 5 sets out data used and the empirical strategy. Section 6 presents the main results and section 7 a variety of robustness checks. Section 8 concludes.

2. Existing theory and evidence

This paper is motivated by the following observations about the literature. First, although the field has made strong methodological advances, in terms of overcoming endogeneity concerns and exploiting sub-national variation, the study of the 'biggest culprit' resources has lagged behind. Second, there is a need to study the effect of natural resources on conflict at multiple geographical levels of analysis, which could reconcile contradictory results from country-level and sub-national studies.

2.1. Empirical evidence

The relationship between natural resources and conflict has been the subject of a plethora of studies. Early studies employed pooled panel regressions at the country level, to investigate the relationship between export, production or presence of various natural resources and conflict onset (Collier and Hoeffler 2004; Fearon and Laitin 2003), duration (Collier, Hoeffler, and Söderbom 2004; Fearon 2004), and intensity (Lujala 2009).

With regard to diamonds in particular, results are mixed and seldom replicated. Primary diamonds have been found to be positively (Ross 2006) negatively (Lujala, Gleditsch, and Gilmore 2005)[i] and unrelated (Lujala, Gleditsch, and Gilmore 2005) to conflict onset. No relationship between secondary diamonds and conflict onset is found in a number of studies, unless we consider separatist conflict only (Ross 2006), ethnic conflict only (Lujala, Gleditsch, and Gilmore 2005) or only secondary diamonds mined in the 'conflict zone' (Lujala 2010). Lujala (2010) finds secondary diamonds to be related to longer conflict duration, Ross (2006) finds no relationship for either diamond type, and Humphreys (2005), aggregating both types, finds diamond production to be related to shorter conflict. In the only study on diamond and conflict intensity, secondary diamonds mined in the 'conflict zone' are found to increase the number of deaths from conflict (Lujala 2009).

Pooled panel regressions are subject to serious concerns regarding endogeneity: resource-producing and non-resource-producing countries typically differ on a whole range of dimensions potentially related to conflict, making causal interpretations difficult (Brunnschweiler and Bulte 2009; Brückner and Ciccone 2010; Berman et al. 2017). Recognizing this, a range of papers exploit variation over time in the international price of hydrocarbons, minerals or agricultural commodities, and variation across country in the production of these resources (Bazzi and Blattman 2014; Besley and Persson 2009; Brückner and Ciccone 2010; Ciccone 2018). Others exploit variation in the timing of oil or mineral discoveries (Lei and Michaels 2014; Bell and Wolford 2015; Smits et al. 2016) or an instrumental variable strategy (Hunziker and Cederman 2017). Increasingly, studies investigate the impact of natural resource price shocks or discovery at the sub-national level (Dube and Vargas 2013; Berman et al. 2017; Maystadt et al. 2014; Arezki, Bhattacharyya, and Mamo 2015; Mcguirk and Burke 2018; Sanchez de la Sierra 2014).

Despite these methodological advances, the study of what some consider the 'biggest culprit' resources - lootable, labour-intensive resources like gems (Le Billon 2001; Fearon 2004)- has lagged behind. Although Bazzi and Blattman (2014) and Berman et al. (2017 – as a robustness check only), do include diamonds in their 'basket' of commodities, they can by their own admission only take into account formal exports and large formal mines and exclude informal small mining operations, even though those are anecdotally most strongly linked to conflict (Keen 2005; Dietrich 2000).

For other resources, no clear consensus has emerged on the relationship between natural resources and various aspects of violent conflict. Results from country-level and subnational studies frequently contradict each other. Bazzi and Blattman (2014) find oil price shocks to be related to shorter, less intense conflict at the country level, whereas Dube and Vargas (2013), find that high oil prices are related to greater intensity of violence at the municipality level in Colombia. Although studies at the country level typically find positive associations between oil and mineral discoveries and conflict (Lei and Michaels 2014; Bell and Wolford 2015; Smits et al. 2016), Arezki et al. (2015) find that oil and mineral discovery decreases conflict at the sub-national level.

2.2. Theoretical mechanisms

Numerous theoretical mechanisms connecting natural resources and conflict have been proposed (Humphreys 2005). Among those receiving the greatest attention are: the rapacity, opportunity costs and state capacity mechanism.

The rapacity mechanism is also called 'natural resources as a prize' or 'greed'. Humphreys (2005) remarks that there exist three variants to this mechanism. In all these, natural resources raise the returns to conflict. First, natural resources may be a prize obtained through dominating or overthrowing the central government, particularly in countries where institutions are weak (Besley and Persson 2009; Caselli and Coleman 2013). Second, armed groups may earn revenue from natural resources by mining these themselves, or by taxing or extorting those who produce them, companies and small-scale miners (Addison, Le Billon, and Murshed 2002). Third, natural resource revenue can be extracted from local government, through abducting, extorting or colluding with local politicians (Dube and Vargas 2013).

The opportunity cost mechanism posits that labour-intensive natural resources increase wages and income to households, thereby increasing the opportunity costs of conflict and the cost of recruitment (Dal Bó and Dal Bó 2011).

The state capacity mechanism highlights that natural resource revenue gives central government the incentive and capacity to defend itself (Snyder and Bhavnani 2005; Bazzi and Blattman 2014; Olsson 2007). A related argument applicable to non-state armed groups holds that taxable natural resources give armed groups the incentive to become stationary bandits and establish a monopoly of violence, rather than pillage (Sanchez de la Sierra 2014). In contrast to the first mechanism, both the opportunity cost and state capacity mechanism predicts a negative relationship between natural resource production and conflict.

These three mechanisms work at different geographical levels of analysis, though empirical studies typically only investigate one[ii]. The rapacity mechanism works at the country level, in the region where the resource is produced, or at the level of the local government, depending on which variant one has in mind. The state capacity mechanism operates at the country level. For the opportunity cost mechanism, the level of operation depends on the extent to which labour markets are integrated and higher wages spill over to other areas in the country. This realization could reconcile superficially contradictory results from country and sub-national level studies: at the country level, oil may increase state capacity to defend (Bazzi and Blattman 2014), but sub-national studies, which explicitly control for these country-level trends, may still find that violence concentrates in locations where natural resources provide returns to conflict for armed groups (Dube and Vargas 2013; Berman et al. 2017).

The contribution of this paper is therefore threefold. First, it constructs a new metric for diamonds, diamond propensity, which is arguably exogenous to conflict and predicts using geology where lootable, labour-intensive diamonds are likely to be. Second, it is the first to investigate the relationship between lootable, labour-intensive gems and conflict using variation in presence of resources with a country, and variation in price over time. Third, it investigates the relationship between diamonds and conflict at both the country and the sub-national level.

3. A simple theoretical model of lootable, labour-intensive resource production and violent conflict

This section provides the intuition behind a simple theoretical model that incorporates mining of a labour-intensive, lootable resource, looting and rebellion. The formal model can be found in the online Appendix.

The model reproduces the familiar result that an increase in the price of a lootable, labour-intensive natural resource *decreases* the intensity of violence due to an opportunity cost effect (Dal Bó and Dal Bó 2011). Unique to this model however, results suggest that this effect is not uniform across geographical levels of analysis. Predictions indicate that although an increase in the price of a lootable labour-intensive natural resource *decreases* the intensity of violence in the country as whole, it *increases* intensity of violence in the region where this resource is produced due to a rapacity effect.

Consider a country with a fixed amount of labour that can be employed in three sectors: (1) mining of a lootable, labour-intensive natural resource; (2) looting, expropriating a share of mining production; (3) rebellion, attempting to overthrow the government to obtain some share of government revenue. The sectors can operate at two geographical locations within the country: the capital, short for any location strategic to government, and the natural resource-rich region. In the simplest incarnation of this model, mining and looting can only take place in the natural resource-rich region and rebellion can only take place in the capital.[iii] The looting and rebellion sectors are violent. The amount of labour employed in the looting and rebellion sectors combined is taken as an indicator for intensity of violence in the country as a whole, the amount of labour employed in the looting sector is an indicator for the intensity of violence in the natural resource-rich region. In the simplest form of the model, there is a single wage rate that is equal across sectors and locations in equilibrium.[iv] In equilibrium, all labour is employed.

The online Appendix sets up this model formally, and derives predictions on the impact of an increase in the price of a lootable, labour-intensive natural resource on the intensity of violence in the resource-rich region and the country as a whole. The intuition behind these results is straightforward. If the price of the lootable, labour-intensive natural resource increases, both mining and looting become more productive: the product being mined and looted is now more valuable. Wages in the natural resource-rich regions increase. This induces rebels to move from the capital to the natural resource-rich region to become either miners or looters, until the wage rates across the regions again equalize. As some rebels become non-violent miners, the total amount of violence in the economy *decreases* in response to the resource price increase. However, as there are now more looters, violence in the natural resource-rich region *increases*.

The model also replicates a result obtained by Besley and Persson (2009): an increase in the exogenous flow of revenue to government, which could include revenue from a different, taxable natural resource, increases the intensity of conflict.[v]

This straightforward intuition illustrates that an increase in the price of a lootable, labour-intensive natural resource can have different effects at different geographical levels of analysis: a decrease in intensity of violence overall, yet a concentration of violence in regions producing this resource.

4. Case study evidence

4.1. Sierra Leone: four 'puzzling' stylized facts

Before taking these predictions to a large-N dataset, it is useful to sense-check whether these are at all plausible by briefly considering the archetypical diamond-fuelled conflict, that in Sierra Leone. These predictions are indeed consistent with four otherwise puzzling stylized facts about the conflict in Sierra Leone (1991-2002).

Diamonds in Sierra Leone are a lootable, labour-intensive resource: the armed group Revolutionary United Front (RUF) reputedly derived a great amount of revenue from secondary diamonds (Keen 2005) and it is estimated that up to 500,000 people are employed in secondary diamond mining (Maconachie and Binns 2007). Government received hardly any diamond revenue (Snyder and Bhavnani 2005; Keen 2005).

Figure 1 displays the location and intensity of violence for the years of this conflict that the diamond price was highest (1993) and lowest (1995) respectively[vi] as well as the location of rivers likely to carry secondary diamonds. At peak diamond price, violent activity was indeed concentrated around diamondiferous rivers. However, in 1995, the RUF marched on the government stronghold, the capital Freetown, coming to within 40 kilometres of it (Hirsch 2001).

Three things about this picture are superficially puzzling. First, if the RUF was exclusively interested in looting diamonds, why did it move towards Freetown at all (Keen 2005)? Second, why did the RUF gain vis-à-vis the government when the diamond price was lowest? The RUF deriving revenue from secondary diamonds would suggests that its military advantage would decrease with the diamond price. Third, why was violence more intense when the diamond price was lowest? A simple rapacity story would suggest less intense violence at a lower diamond price.

Figure 1: location and intensity of violence in Sierra Leone

Fourth, despite clear links between diamonds and violence, diamonds in Sierra Leone have positive aspects. Keen (2005) mentions that diamond mining is 'safety-valve' employment for marginalized groups that might otherwise be ready recruits for armed groups. In a survey in two villages about 40 kilometres away from a major diamond centre, around 40% of respondents indicated they felt they directly benefited from mining, mainly through the sale of foodstuffs to miners (Maconachie and Binns 2007).

The simple theoretical model presented is consistent with these four otherwise puzzling facts. It allows the RUF switch between looting and fighting the government, and thus to move on Freetown. It suggests that a lower diamond price decreases recruitment costs, allowing the RUF to gain vis-à-vis the government at low diamond prices. It predicts increased overall intensity of violence with a decrease in the diamond price. Lastly, it is consistent both with the observation that rebels gain revenue from diamond mining, while diamond mining also provides an alternative livelihood to potential recruits.

It is not my intention to push this analogy too far. There are many other factors affecting the pattern of violence in Sierra Leone. In particular, it should be noted that the RUF invaded Sierra Leone from Liberia in the South-East, which borders the diamond-rich areas, and that the RUF briefly controlled several rutile and bauxite mines located relatively close to Freetown (Hirsch 2001). This section merely shows that the theoretical model presented is not obviously inconsistent with the most prominent example of 'diamond-fuelled' conflict. In this, it does better than explanations based simply on rapacity or 'greed'.

4.2. **Trade-offs between activities**

In the model presented, armed groups engage in looting at the expense of rebellion and *vice versa*, whereas individual workers choose between joining an armed group and mining. It is at least plausible that actors face similar trade-offs in reality.

First consider the trade-off between rebellion and looting. In Sierra Leone, where at times both parties to the conflict seemed more interested in colluding to loot than fighting each other, the Revolutionary United Front (RUF) did march on Freetown, the government stronghold (Keen, 2005). Other insurgent groups switch between rebellion and looting as well. The Kachin Independence Organization (KIO) in Myanmar switched from fighting the government, to signing a formal cease fire with the government in order to exploit natural resources in areas they controlled, to breaking this cease fire to re-engage the government (Brenner, 2015).

Furthermore, individuals do move between armed groups and mining. In Sierra Leone, 10,000 miners expelled by the government from mining areas were "easy recruits" for the RUF, as they had no access to alternative livelihoods such as agriculture (Keen 2005). A reverse move has been reported in Angola, where there was a "rush to Lunda diamond field by former combatants" around 1992 (Dietrich 2000).

5. Data and empirical strategy

5.1. **Diamond data**

The study of natural resources and conflict has been hampered by the concern that natural resource production is endogenous to conflict, and by under- and misreporting of small-scale natural resource production. Therefore, I propose a new metric for the presence of diamonds: diamond propensity. This metric is based on geological characteristics of an area, making it arguably exogenous to conflict, and able to capture potential for small-scale diamond production, even if this goes unrecorded by production statistics.

5.1.1. Challenges studying natural resources and conflict

Studying the relationship between natural resources and conflict is challenging because natural resource production and exports may be endogenous to conflict, and because getting accurate data on small-scale and artisanal mining is difficult.

Theoretical models suggests that a country's status as a resource exporter (Garfinkel, Skaperdas, and Syropoulos 2008), the volume produced (Dal Bó and Dal Bó 2011) and the pace and method of extraction (van der Ploeg and Rohner 2012) is endogenous to violent conflict. In the case of diamonds, this problem is compounded because the type of diamonds produced, primary or secondary, may be endogenous to conflict.

A second challenge is adequately capturing small-scale and artisanal mining[vii]. In the case of diamonds, this type of mining has been most strongly linked to conflict anecdotally. Datasets on mines typically do not capture small-scale mines (Berman et al. 2017) and secondary diamond production is also typically excluded from formal production and export statistics (Keen 2005; Snyder and Bhavnani 2005; Oomes and Vocke 2003). In other cases, secondary diamond production was misreported as having taken place in countries that neighbour a country in conflict (Olsson and Congdon Fors 2004). DIADATA is the most comprehensive dataset of primary and secondary diamond occurrences available (Gilmore et al. 2005). However, a close reading of the codebook reveals numerous and partially unavoidable difficulties in classifying secondary diamond producing areas: difficulties in assigning potentially vast secondary diamond fields a single point coordinate, lack of accurate spatial information, and the potential for more secondary mining sites at unknown locations.

5.1.2. A new measure: diamond propensity

This section describes a new metric for the presence of primary and secondary diamonds: diamond propensity. This makes use of geological regularities in where diamonds can be found.

Primary diamonds can be found where host rock, kimberlite or lamproite, coincides with areas particular geological age, called archons. This regularity is known in geology as "Clifford's rule" (Janse 1994; Clifford 1966). Primary diamond propensity is therefore based on two data sources: coordinates of known instances of the occurrence of kimberlite and lamproite (Faure 2010) and polygons classifying the age of the bedrock (Chorlton 2007). A count of the number of intersections of kimberlite or lamproite and an archon in a given area is the proposed indicator for primary diamond propensity (Figure 2 illustrates this). There are 803 such intersections in the continent of Africa.

Secondary diamonds are eroded away from their host rock, mostly by rivers. Economically viable deposits of secondary diamonds can be found up to 600 kilometres away from the host rock. It is not the case that the viability of secondary diamond deposits decreases with distance to the host rock: the erosion process concentrates diamonds, breaks up diamonds with flaws, and rounds off edges implying less weight-loss at the cutting stage. Thus, the most attractive secondary deposits are as a rule found at considerable distance from their primary source (Sutherland 1982).

To construct secondary diamond propensity, I use a comprehensive dataset of the world's rivers and their flow direction (Lehner, Verdin, and Jarvis 2006). Of these rivers, I select all that are located within 750 meters (the radius of the largest known kimberlite deposit (Janse and Sheahan 1995)) of an intersection between kimberlite or lamproite and an archon. If no rivers are selected for an intersection, I select the closest river, to account for any inaccuracies in spatial information. In practice, the selected closest river is at most 5 kilometres away from the intersection. Starting from this selected river, I furthermore select all river segments downstream from it, within a radius of 600 kilometres from the source intersection. Figure 2 illustrates this process. The total length in kilometres of all thus selected rivers segments in a given area is the proposed measure of secondary diamond propensity.

Figure 2: Primary and secondary diamond propensity

The newly constructed measures of diamond propensity are correlated to existing measures of diamond occurrence. Table 1 shows the correlation between primary and secondary diamond propensity and the number of occurrences of primary and secondary diamonds according to DIADATA at two levels of analysis: the country level, and 0.5 by 0.5 degree grid cells. At both levels of analysis, the correlation is strongly statistically significant. For primary diamonds the size of the coefficient is roughly as expected, as about one in ten host rock deposits is diamondiferous (Janse and Sheahan 1995). In only a small percentage of cases, between 5.7% and 17.3% of all countries, does diamond propensity give a 'false positive' - i.e. predicts potential for diamonds whereas DIADATA records no diamond finds - or a 'false positive'. More detail on specific false positives and negative is given in the online Appendix.

Table 1: Correlation between diamond propensity and existing measures of diamond occurrence

Even though diamond propensity is based on geological data, there may still be some concerns regarding endogeneity if the discovery of kimberlite and lamproite is endogenous to violent conflict. Given that the majority of known kimberlite and lamproite has not been prospected for diamonds (Faure 2010), I argue that diamond propensity is at least less sensitive to these concerns than existing measures. Furthermore, to mitigate concerns that discovery of kimberlite or lamproite is somehow driven by characteristics of a country or area related to conflict, I present results from a placebo test using off-archon kimberlite or lamproite.

5.2. Other data

Data on violent conflict is taken from two sources: the Uppsala Conflict Data Programme Geo-referenced Event Dataset Version 4.1 (UCDP) and the Armed Location Conflict and Event Dataset Version 5 (ACLED). Both datasets record violent events and the number of fatalities for each event, and cover all 52 major African countries. According to UCDP, 32 countries, including 18 with diamond propensity, experienced some conflict event over the research period. ACLED records conflict events in 49 countries, including 25 with diamond propensity.

To increase comparability between ACLED and UCDP, I omit from ACLED events all non-violent events and all riots. Events associated with inter-state armed conflict are also omitted from both datasets. UCDP distinguishes three conflict event types: armed conflict (between government and a non-state armed group), non-state conflict (between two non-state armed groups) and one-sided violence (between government or a non-state armed group and civilians). For ACLED, events coded as ‘battle’ and involving “Military forces of [country]”, “Police forces of [country]” or “Government of [country]” are considered equivalent to the first type, other events coded as ‘battle’ to the second type and ‘violence against civilians’ to the third type. At the grid level, events that are not recorded with a sufficient level of geographical accuracy to be assigned to a single 0.5 by 0.5 degree grid-cell are omitted from both datasets.

Data on the diamond price is taken from Bloomberg.[viii] This is an index of rough diamond prices, as diamonds of different weight in carats, clarity and colour are traded at different prices. The diamond price in period t is the price at the close of previous period (year, quarter or month). Closing prices are least affected by missing values. This data is available from Q3 2004 to Q2 2015, which limits the research period to those dates. Figure 3 displays the change in diamond price over this period: there are considerable fluctuations in the diamond price. Section 0 investigates whether the rough diamond price is endogenous to conflict in diamond producing countries, finding no convincing evidence that this is the case.

Figure 3: Rough diamond price

Although using the Bloomberg diamond price data limits the research period, it is the most suitable data available. Bazzi and Blattman (2014) use a rough diamond price data series that covers a longer period, but this data relies on price estimations as well as forward- and back-casting, only varies by year, and contains no variation from 2002 onwards. This data is based on *estimates* of the rough diamond price for 1976-2002 (Bergenstock 2004), which are back-cast using South African value of production per carat. From 2002 onwards (all of the current research period), Bazzi and Blattman impute the 2002 diamond price. Consequently, there is no variation in the diamond price from 2002 onwards at all, an assumption that seems particularly unrealistic given Figure 3. Berman et al. (2017) use Rapaport prices for polished diamonds for 1997-2010, which also only vary by year. The polished diamond price and rough diamond price frequently follow different trends over this period (Bain and Company 2011; Bain And Company 2013) and the polished diamond price is essentially irrelevant for African countries which possess virtually no polishing industries.

Data sources for remaining variables, as well as descriptive statistics for the main variables of interest, are given in the online Appendix.

5.3. **Empirical strategy**

The theoretical model presented in section 3 predicts that an increase in the price of a lootable, labour-intensive resource can have different effects at the country and sub-national level. The sub-national level of analysis is the 0.5 by 0.5 degree grid cell, corresponding to about 55 kilometre at the equator, derived from PRIO-GRID version 2.0. Using grid-cells avoids concerns regarding endogenous formation of sub-national administrative units.

At the country level, the main specification of interest is:

$$Y_{ct} = \boldsymbol{\alpha_c} + \boldsymbol{\gamma_t} + \beta_1\, prim_c * price_t + \beta_2 \sec_c\ *\ price_t + \varepsilon_{ct} \tag{1}$$

where Y_{ct} is the intensity of violence in country c in quarter t, α_c and γ_t are sets of country and period-fixed effects respectively, $prim$ indicates primary diamond propensity, sec indicates secondary diamond propensity and $price$ is the rough diamond price index at the close of the previous period. Standard errors are clustered at the country level.

Coefficients β_1 and β_2 capture the effect of the diamond price increase in a country with geological propensity to have primary and secondary diamonds respectively. Following the theoretical model presented, β_2 is hypothesized to be negative at the country level. β_1 is hypothesized to be positive, although this prediction is ambiguous if we allow for government defence (see online Appendix).

The equivalent specification at the grid-cell (subscript i) level is:

$$Y_{ict} = \boldsymbol{\alpha_i} + \boldsymbol{\gamma_{ct}} + \beta_1\, prim_i * price_t + \beta_2 \sec_i\ *\ price_t + \varepsilon_{ict} \tag{2}$$

where γ_{ct} is a set of country-period fixed effects. Note that with the inclusion of these fixed effects, β_1 and β_2 capture the effect of the interaction terms between diamond propensity and price relative to the overall country trend. Standard errors are clustered at the grid-cell level. Both specifications are estimated using a multi-way fixed effects model (Correia 2016).

At the grid-cell level β_2 is hypothesized to be positive.

Motivated by the choice of dependent variable and the theoretical model in section 3, specifications (1) and (2) include diamond price levels, rather than diamond price shocks. The dependent variable in the present analysis is a level – the level of intensity of violence. The theoretical model presented predicts that levels of secondary diamond production and violence are continuously higher at higher levels of the world diamond price. A specification investigating the effect of diamond price shocks on changes in violent conflict – particularly violent conflict onset – addresses a conceptually different question, which is explored in the online Appendix. Specifications (1) and (2) can be regarded as a reduced form. The corresponding specification of interest would be an IV model, using primary and secondary diamond propensity to instrument for primary and secondary diamond production. However, as stated before, reliable data on diamond production distinguishing between primary and secondary production is not available. Since there have not been large diamond discoveries over the research period (the last recorded was in 1997) and opening of new mines is rare (Bain and Company 2011), it is not possible to use discoveries or mine openings as a source of exogenous variation.

To mitigate concerns regarding the endogeneity of the diamond price, specifically the concern that conflict in diamond-producing countries in Africa affects the world diamond price, I estimate the following Instrumental Variable (IV) model at the country level:

$$\ddot{Y}_{ct} = \boldsymbol{\alpha_c} + \beta_1\, \widehat{\ddot{prim_c * price_t}} + \beta_2\, \widehat{\ddot{\sec_c * price_t}} + \varepsilon_{ct} \tag{3}$$

And at the grid-cell level:

$$\ddot{Y}_{ict} = \boldsymbol{\alpha_i} + \beta_1\, \widehat{\ddot{prim_i * price_t}} + \beta_2\, \widehat{\ddot{\sec_i * price_t}} + \varepsilon_{ict} \tag{4}$$

where the hat indicates predicted values from the first stage. Instruments are Russian export volume interacted with primary and secondary diamond propensity respectively. Russia is the largest non-African diamond exporter by volume and value according to Kimberley Process Statistics. The identifying assumption for this IV specification is that Russian diamond production affects the diamond price, but not violent activity in Africa through any channel other than the diamond price. To decrease computation time, all variables are expressed as deviations from the period mean (country level) or the country-period mean (grid-cell level) and quarter-fixed effects and country-quarter fixed effects are omitted. Hence, $\ddot{Y}_{ct} = Y_{ct} - \bar{Y}_t$ and $\ddot{Y}_{ict} = Y_{ict} - \bar{Y}_{ct}$ etc., where the upper bar indicates the mean.

6. Main results

6.1. **Diamond price and the intensity of violent conflict**

Table 2 displays the main results at country and grid-cell level. Four indicators of conflict intensity are taken as dependent variables: the number of violent events and the number of fatalities from such events as recorded by ACLED and UCDP.

Table 2: Main results

Results at the country level (Panel A) indicate that an increase in diamond price is related to an *increase* in the intensity of violent conflict in countries that have a geological propensity towards primary diamonds, but to a *decrease* in conflict intensity in countries with secondary diamond propensity. These results are statistically significant at the 5% or 10% level for three out of the four indicators of conflict intensity. Taking the number of violent events from ACLED as a dependent variable, coefficients have the expected signs, but are not statistically significant. These results imply that when the diamond price increases, the overall intensity of violence *decreases* in countries geologically likely to be rich in secondary diamonds, a lootable, labour-intensive resource. Results furthermore suggests that an increase in the diamond price is related to an *increase* in the overall intensity of conflict in countries with a propensity towards primary diamonds, which are likely to contribute to government revenue.

To get a sense of the size of these effects, consider an increase in the diamond price of one standard deviation from its mean level. Upon such an increase in diamond price, the model predicts an increase in conflict intensity by 87 deaths recorded by UCDP in countries with above-mean primary diamond propensity, compared to an increase by 59 deaths in countries with below-mean primary diamond propensity. A back-of-the-envelope differences-in-differences calculation suggests that countries with above-mean primary diamond propensity experience an increase in intensity of violence by 28 deaths, compared to the trend in other countries. A similar calculation suggests a decrease of 81 deaths in countries with above-mean secondary diamond propensity upon a one standard deviation increase in diamond price. Since the mean number of deaths recorded by the full UCDP dataset is 145 per country per quarter, these numbers are economically significant. Estimates using ACLED fatality data are similar: an increase of 37 deaths in countries with above-mean primary diamond propensity, and a decrease of 131 deaths in countries with below-mean secondary diamond propensity. The mean of number of deaths per country per quarter in the full ACLED dataset is 157. Since there are 14 countries with above-mean secondary diamond propensity, the total decrease in fatalities due to violent events upon a one standard deviation increase in the diamond price is estimated to be between 1133 (UCDP) and 1832 (ACLED) for all African countries.

Panel B of Table 2 displays results at the grid-cell level. These suggest that, controlling for country-level trends, an increase in the diamond price is related to an *increase* in the intensity of violence in grid-cells with secondary diamond propensity. These results hold for three out of four indicators of conflict intensity (columns 1 to 3), but are not statistically significant in column (4) although the coefficients carry similar signs. Overall, results at the grid-cell level suggest that with an increase in the diamond price, violent activity concentrates in areas geologically likely to be rich in secondary diamonds.

The suggested magnitude of the effect is smaller at the grid-cell level compared to that at the country level, yet still economically significant. The model predicts that when the diamond prices increases by one standard deviation, the number of fatalities recorded by ACLED[ix] increases by 0.05 in grid-cells with any secondary diamond propensity, compared to the trend in other grid-cells. The mean number of fatalities per grid-cell is 0.67 per grid-cell per quarter in the full ACLED dataset. For 718 cells with secondary diamond propensity across Africa, the total increase in fatalities from violent events is estimated to be 36 per quarter, relative to country trends.

The interaction term between primary diamond propensity and diamond price is *negatively* related to the intensity of violence in column 2. This could be explained if we consider that primary diamond mines can be relatively easily protected by private security forces, and that the incentives to do so increase with the diamond price. However, results for this variable are not statistically significant for any of the other indicators of intensity of violence.

In sum, in accordance with the theoretical model presented in section 3, main results suggest that an increase in the diamond price is related to a *decrease* in overall intensity of violence in countries with a lootable, labour-intensive resource, but to an *increase* in intensity of violence in sub-national areas geologically likely to contain this resource. Overall, intensity of violence declines, but violence concentrates in resource-rich regions.

6.2. **Diamond price and economic activity: the opportunity cost mechanism**

In the theoretical model, the overall decrease in violence as the diamond price rises is driven by an increase in economic activity in diamond-mining areas (the opportunity cost mechanism). I find evidence at the grid-cell level that economic activity in diamond-mining areas indeed increases with the diamond price.

Table 3 column 2 investigates whether an increase in the diamond price leads to an increase in economic activity at the country level, as measured by GDP per capita. Results are not statistically significant, nor are they statistically significant when taking GDP per worker as an indicator for economic activity (not shown). This may not be entirely surprising, as official GDP statistics are unlikely to reflect secondary diamond production. Table 3 column 1 also fails to provide evidence for the government capacity mechanism at the country level: an increase in diamond price is not related to increased military expenditure as a percentage of GDP (or to military expenditure in dollars – not shown).

At the grid-cell level, economic activity is proxied by the quantity of light emitted at night. Table 3 displays the results obtained when regressing nightlight on the interaction terms between the diamond price and primary and secondary diamond propensity respectively. Note that data on nightlight is only available by year. In accordance with the opportunity cost mechanism, column 3 suggests that an increase in the diamond price is indeed related to an increase in economic activity in areas with a propensity towards both primary and secondary diamonds. Columns 4 and 5 of Table 3 include interaction terms of the diamond price with several spatial lags of secondary and diamond propensity. These suggest that a diamond price increase has positive spill-overs to economic activity in grid-cells adjacent to cells with secondary diamond propensity, and in grid-cells adjacent to those. Since the size of these grid-cells is 55 kilometres at the equator, these results suggest that an increase in the diamond price can affect economic activity over 100 kilometres away from areas geologically likely to have secondary diamonds. The effect of a diamond price increase on grid-cells adjacent to areas with primary diamond propensity dissipates more quickly with distance: we can see no effect on grid-cells two cells removed from an area likely to have primary diamonds and the coefficient on the first spatial lag is only half the size of its unlagged counterpart.

By contrast, there is little evidence that an increase in the diamond price has negative spill-overs to areas adjacent to cells with secondary diamond propensity, in terms of an increased intensity of violence (columns 6 to 8 of Table 3). In what follows, I will focus on a single indicator of intensity of violence to promote readability. I opt for the number of UCDP events, since this indicator illustrates the main results best, at both the country and grid level. However, when results using the other indicators differ meaningfully, this will be indicated in the text. None of the interaction terms including the spatial lags of secondary diamond propensity are statistically significant related to the number of violent events recorded by UCDP in columns 7 and 8. The coefficients on the interaction terms including primary diamond propensity are statistically significant, possibly reflecting an increased incentive for mining companies or government to protect the vicinity of mines. However, this is unique to the regressions with UCDP events as a dependent variable.

The results in this section suggest that an increase in diamond price indeed increases economic activity in areas with secondary diamond propensity, and that this has spill-over effects for adjacent areas. These spill-over effects are less strong for areas with primary diamond propensity. There is little evidence that a diamond price increase has negative spill-over effects in terms of increased intensity of violence for areas adjacent to cells with secondary diamond propensity. Considering these results, it becomes easier to see why a diamond price increase would *decrease* the intensity of violence overall for a country rich in a labour-intensive, lootable resource, but *increase* intensity of violence in sub-national areas rich in this resource: the increase in economic activity, representing an increase in the opportunity costs of conflict, spills over to a wide area, whereas the increase in intensity of violence due to an increase in the returns to looting remains contained to the resource-producing areas.

Table 3: Diamond price and economic activity

6.3. Distinguishing different types of violence

In the theoretical model, results at the country level are driven by changes in the number of rebels and looters, while results in the natural resource rich region are driven by changes in the number of looters only. Rebellion and looting may be translated empirically as armed conflict events and one-sided-violence events respectively. The main results appear to be driven by the expected event types, although results are stronger at the grid-cell level than at the country level.

Table 4 investigates which of these three event types drives the main results. At the country level, it reveals no statistically significant results for any UCDP event type, although the coefficients obtained are much larger when taking armed conflict events and one-sided violence events as dependent variables compared to non-state conflict events. Results obtained using comparable ACLED event types (which are statistically significant, but not shown), also suggest that main results at the country level are driven by armed conflict and one-sided violence events, as opposed to non-state conflict events.

Columns 4 to 6 clearly suggest that at the grid-cell level, main results are driven by one-sided violence events. For UCDP conflict events, there is no qualitative difference in results when distinguishing between one-sided violence events perpetrated by the government versus a non-state armed actor. For ACLED data (events and fatalities), the interaction term including secondary diamond propensity is significantly related to violence against civilians by non-state armed actors only.

Table 4: Different types of violence

7. Robustness

The main results are reasonably robust to several ways to address the potential endogeneity of the diamond price, tests of the validity of the propensity measures, adding additional control variables (online Appendix), distinguishing between conflict onset and intensity (online Appendix) and employing different econometric methods of estimation (online Appendix).

7.1. **Endogeneity of the diamond price**

The world diamond price may be endogenous to conflict. Specifically, the diamond price may change in response to intensity of conflict in diamond-producing countries. However, the oligopolistic structure of the diamond market makes this less likely. Observers of the market mention the strength of monopolist De Beers' position (before 2000) (Bergenstock 2004) and (after 2000) technical difficulties in Australian diamond mines, changing cultural practices and monetary policies in India and China (Bain And Company 2012) as important factors driving the diamond price.

Even though industry watchers do not mention supply conditions in African countries, the endogeneity of the diamond price to conflict intensity deserves further investigation. Table 5 replicates the main specifications of interest, excluding De Beers' stronghold countries Botswana, South Africa and Namibia from the sample. Main results at the country and grid-cell level are unaffected (columns 1 and 5).

We may furthermore worry that the diamond price is a proxy for global economic conditions. Given the inclusion of quarter-fixed effects, this is a worry only if these conditions affect countries or grid-cells likely to have diamonds differently than others. To mitigate this concern, I run a placebo-test interacting primary and secondary diamond propensity with the price of two other resources, oil and gold. Table 5 shows that the coefficient on the interaction term using secondary diamond propensity is sporadically statistically significant at the 10 % level. However, using the oil and gold price as a placebo does not consistently replicate the main results. The online Appendix furthermore shows results when controlling for the presence of gold, platinum, iron and oil, interacted with their prices. Results are robust to adding these controls.

If the diamond price proxies for global economic conditions, it may also be related to agricultural commodity prices. To investigate this, Table 5 displays a final placebo test, interacting the diamond price with soil suitability to agriculture. A country or grid-cell is classified as high (moderate) soil quality if less than 50% of its area faces (very) severe constraints to maize cultivation. Low soil quality, when more than 50% faces some severe or very severe constraint, is the omitted category. Neither placebo variable is significantly related to the intensity of violence at the country (column 4) or grid-cell (column 8) level.

Table 5: Endogeneity of diamond price

Following Dube and Vargas (2013), Table 6 instruments for the diamond price using the production volume of Russia, the largest non-African diamond producer by volume and value. In the first stage, the correlation between the interaction terms between Russian export volume and primary and secondary diamond propensity respectively and the original interaction terms is statistically significant at the 1% level. F-statistics are very large, and the instrument passes tests for underidentification and weak instruments. The pseudo-R^2 suggests Russian export volume explains about 5% of variation in international diamond price.

Table 6 shows the second stage. At both the country and grid-cell level, results are statistically significant for one indicator of intensity of violence. Taking the remaining indicators as dependent variables, coefficients retain the expected sign, and reassuringly do not decrease (or even increase) in size. However, standard errors increase compared to OLS estimations, so that coefficients are not statistically significant at conventional levels. Overall, a number of main results are sensitive to instrumenting for diamond price with Russian export volume. Yet, this may be due to a lack of precision of the IV estimates rather than concerns of endogeneity.

Table 6: Instrumenting for diamond price with Russian production volume

7.2. **Propensity measures**

Throughout this paper, I have argued that primary and secondary diamond propensity are less subject to endogeneity compared to existing data. However, diamond propensity might still be endogenous to conflict intensity, if there exists some third factor correlated to the presence of kimberlite and lamproite on archons, or rivers downstream from these, that drives a trend in the intensity of violence that is in turn correlated to the diamond price. In particular, areas where kimberlite or lamproite is more likely to be discovered, or areas with rivers – which might be strategic locations in a conflict - might experience a different trend in violence compared to other areas. To investigate this, I generate placebo measures of primary and secondary diamond propensity: the number of kimberlite and lamproite deposits *not* on an archon, and the total length of river segments *upstream* from an on-archon kimberlite or lamproite deposit. Columns 1 and 5 of Table 7 show that the interaction terms between these placebo propensity measures and the diamond price are not statistically significantly related to conflict intensity. These results hold at the country and grid-cell level, for all indicators of conflict intensity.

Since secondary diamonds originate from primary diamond deposits, primary and secondary diamond propensity are correlated. This raises some concerns regarding multi-collinearity when including both variables in a regression. Columns 2 and 3 (country level) and columns 6 and 7 (grid-cell level) of Table 7 therefore show the results obtained when entering the interaction terms including primary and secondary diamond propensity separately. At the country level, coefficients on the interaction terms lose statistical significance. This could be because earlier specifications were plagued by multicollinearity, although we would generally associate this with more imprecisely rather than more precisely estimated coefficients. Alternatively, since the main results show that an increase in the diamond price has the opposite effect in countries with primary and secondary diamond propensity, these effects might cancel each other out when only a single type of diamond is considered. At the grid-cell level, where such counteracting effects were not generally found, the interaction term between secondary diamond propensity and diamond price is still statistically significantly related to conflict intensity when included on its own.

Finally, I convert the continuous propensity measures to binary indicators. At the country level, this is an indicator equalling one if a country has above-mean diamond propensity. At the grid-cell level, this indicator equals one if a grid-cell has any diamond propensity. Results for primary diamond propensity are sensitive to this transformation. Results for secondary diamond propensity are qualitatively unchanged.

Table 7: Investigating propensity measures

7.3. Conflict onset and intensity

It has been argued that violent conflict onset and intensity at the country level are governed by different processes: conflict onset requires overcoming a collective action problem among rebels, whereas increasing conflict intensity does not (Ciccone 2011; Bazzi and Blattman 2014). The online Appendix shows that results at the country-level are driven by intensity of violence rather than by conflict onset.

7.4. Additional controls

The online Appendix shows that results are robust to controlling for the presence of other resources interacted with their price. To mitigate concerns that presence of diamonds is related to waterways, urbanization, suitability for agriculture or mountainousness, and that these areas may display different trends in conflict over time, land-use specific time trends are included.

7.5. Alternative specifications

The online Appendix shows that the main results are robust to: including country-quarter trends rather than country and quarter fixed effects, employing alternative clustering of standard errors, using standard errors with a spatial HAC correction and using a Hurdle model for count data

Results are not an artefact of the Modifiable Aerial United Problem (Harari and Ferrara 2018). Results at the grid-cell level are sensitive to clustering standard errors at the country level.

7.6. Stationarity of diamond prices

The online Appendix presents the results of panel data augmented Dickey Fuller unit root tests, including a time trend and subtracting cross-sectional means as done in the main regression specifications. These tests reject non-stationarity for both interaction terms including the diamond price.

8. Conclusion and policy implications

This paper suggests that an increase in the price of a lootable, labour-intensive natural resource can have a different effect at different levels of analysis: a decrease in intensity of violence overall due to an opportunity cost effect, but an increase in violence locally due to a rapacity effect. It outlines a simple model of lootable, labour-intensive resources and violent conflict illustrating the intuition behind this. This model is consistent with four otherwise puzzling facts about the conflict in Sierra Leone.

Using a new indicator, measuring the geological propensity of an area to hold primary and secondary diamonds, results for all countries in Africa from Q3 2004 to Q2 2015 are consistent with the predictions of the theoretical model. An increase in the international price of diamonds is related to a lower overall intensity of violence in countries with a geological propensity toward secondary diamonds (results suggest 1832 fewer fatalities across Africa), but more intense violence in grid-cells geologically likely to produce this resource (a suggested additional 36 fatalities in total relative to country level trends).

This paper also finds that an increase in diamond price increases economic activity in grid-cells likely to contain secondary diamonds, which spills over to adjacent grid-cells. As such, this paper joins a series of papers that highlight the contribution to livelihoods of small-scale and artisanal mining (Bazillier and Girard 2017; Maconachie and Binns 2007; Hilson and Clifford 2010).

Results presented in this paper resemble those of Berman et al. (2017) and Dube and Vargas (2013), as they suggest that natural resources that allow armed groups to extract revenue at the local level increase violence in those locations. However, this paper suggests that for labour-intensive resources, this effect may be dominated at the country-level by an opportunity cost effect. Contrary to Berman et al. (2017), who study capital-intensive large mines unlikely to trigger such an opportunity cost effect, I do not find evidence for a 'feasibility mechanism': violence spreading as a result of armed groups becoming better funded.

This paper explored the same theoretical mechanisms for diamonds as McGuirk and Burke (2018) do for food crops, although in the case of diamonds predictions for non-producing areas differ. Similar to McGuirk and Burke (2018), this paper finds that higher commodity prices are associated with higher levels of violence in producing areas, as the rapacity effect dominates the opportunity cost effect. However, McGuirk and Burke also find higher levels of violence in non-producing areas, as higher food prices imply a decrease in real wages for net food consumers and an increase in the value of appropriable food surplus. These effects are likely not relevant to the present study, because diamonds are not widely consumed or stored in non-diamond producing areas in Africa.

This paper emphasizes the importance of carefully considering the characteristics of the natural resource under investigation, the mechanisms through which this might be connected to conflict, and the level of analysis at which this mechanism operates. Formulating theoretical models and providing empirical results at multiple levels of analysis, as in this paper, may go some way towards reconciling superficially contradictory results from country level and sub-national studies.

These results have implications for policies regarding 'conflict minerals'. Many of these policies attempt to ban trade in minerals mined in areas where armed groups are active, essentially driving their price down. In case of diamonds, the most prominent policy response is the Kimberley

Process Certification Scheme (KPCS). Taking results at face value, these policies are as 'double-faced' as diamond themselves: they may indeed decrease intensity of violence around mines, but by depriving miners of income, they may increase their vulnerability to be recruited by armed groups. If so, policy makers are faced with choice between two extremely unpalatable options: allowing 'dirty' minerals on the international market or worsening a conflict country's overall situation by decreasing economic activity. Parker et al. (2016), point out a similar dilemma in the case of the DRC and the ban on trade in 3T minerals incorporated in Dodd-Frank Act Section 1502 (Parker, Foltz, and Elsea 2016). Keeping "rebel's best friend" off the international market, while maintaining economic advantages of "farmer's best friend" is clearly no trivial task.

9. References

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[i] For ethnic conflict only

[ii] Exception is (Hunziker and Cederman 2017) for oil.

[iii] Although the online Appendix also provides the intuition behind an alternative set-up, in which rebellion can also take place in the natural resource-rich region.

[iv] Predictions hold when restricting mobility across sections and across regions, see online Appendix.

[v] Although this result does not unequivocally hold if the government can hire labour to defend itself (see online Appendix).

[vi] According to a price index taken from (Bazzi and Blattman 2014)

[vii] See (Saavedra and Romero 2017) for using satellite imagery to identify small-scale gold mines in Colombia.

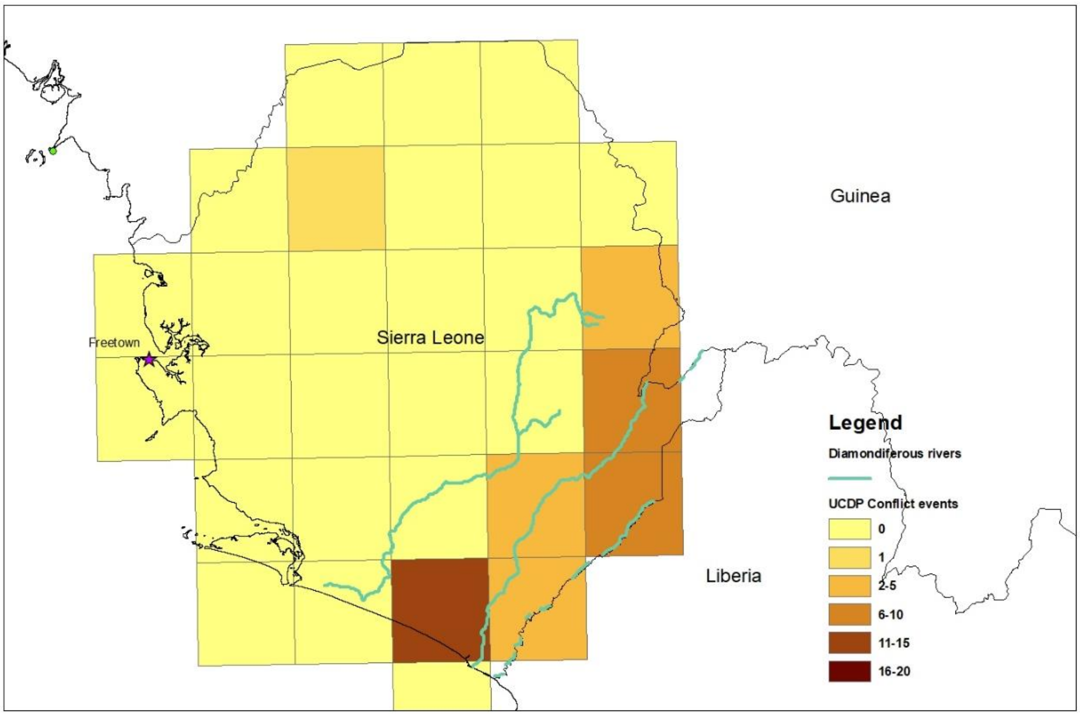
[viii] Series PLPHROAI

[ix] Note that coefficients in the regression using UCDP deaths are not statistically significant.

Tables and Figures

Figure 1: location and intensity of violence in Sierra Leone

Panel A: Sierra Leone, 1993, Diamond price index 112.3



Panel B: Sierra Leone, 1995, Diamond price index 89.17

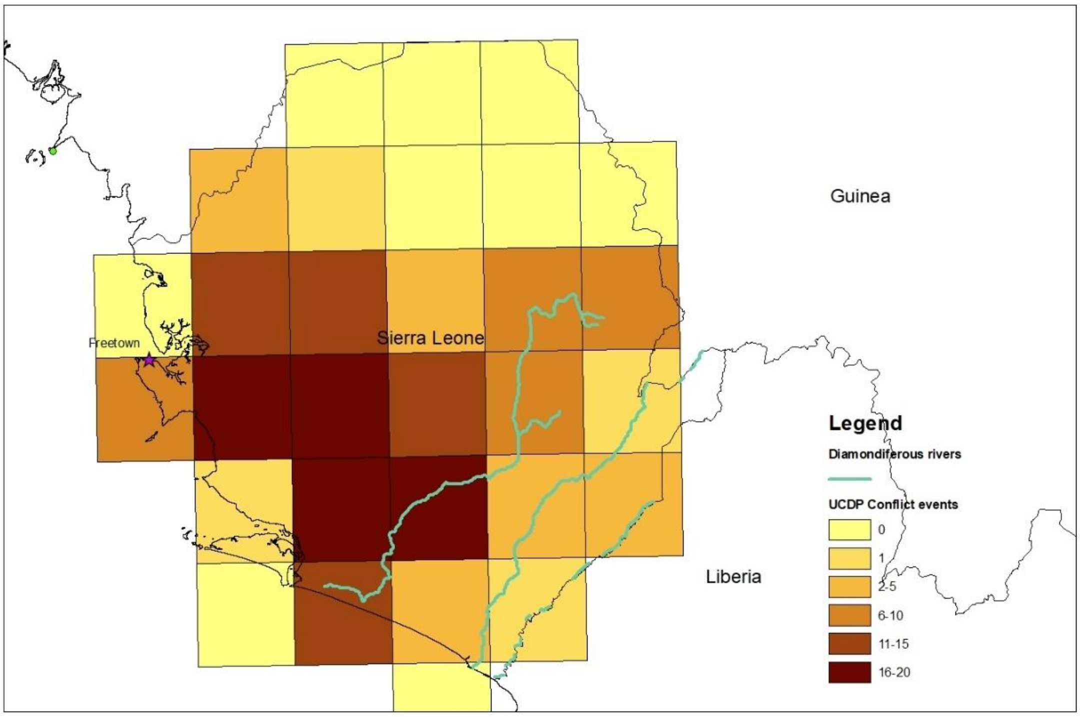
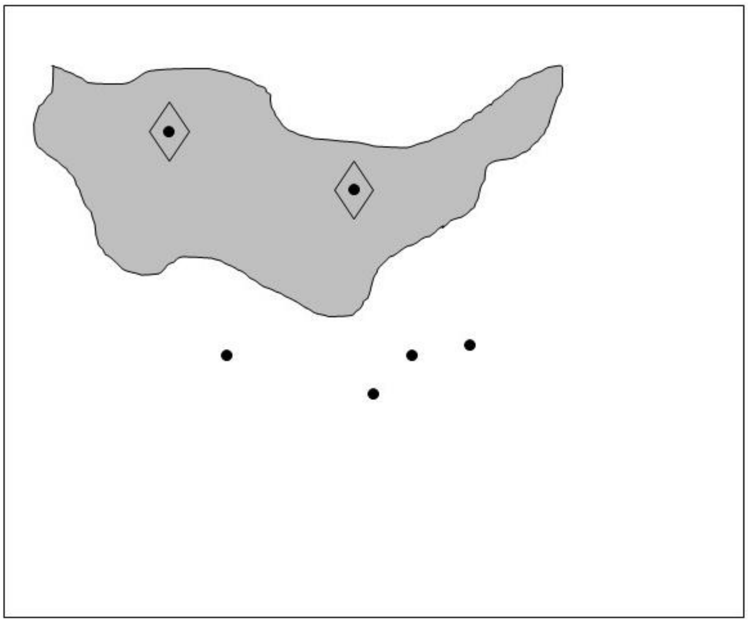


Figure 2: Primary and secondary diamond propensity

Panel A: Primary diamond propensity



Panel B: Secondary diamond propensity

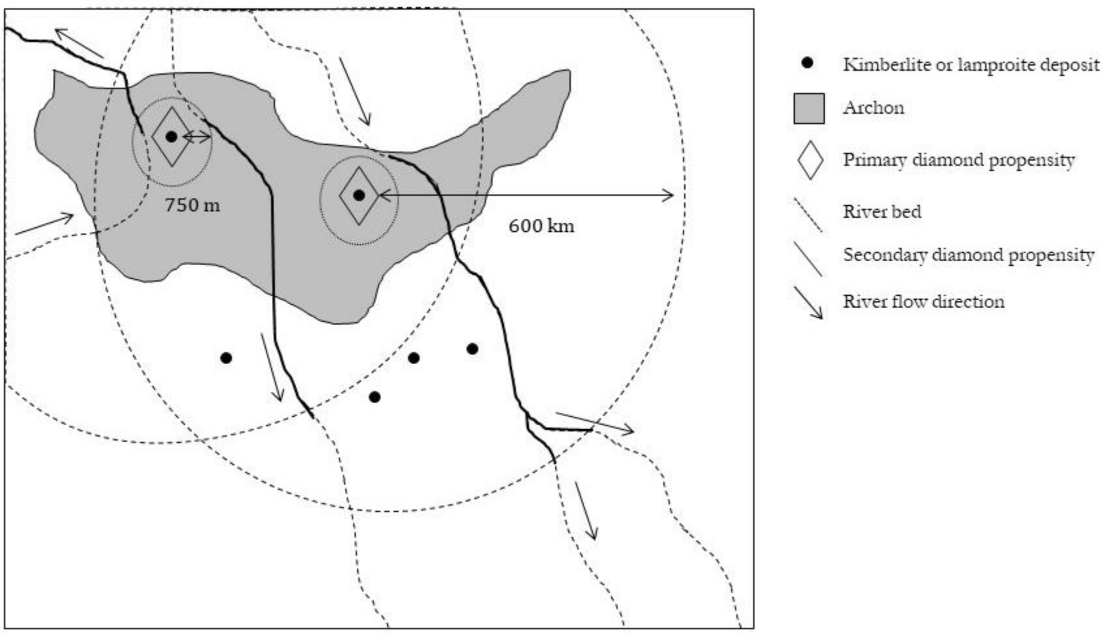


Figure 3: Rough diamond price

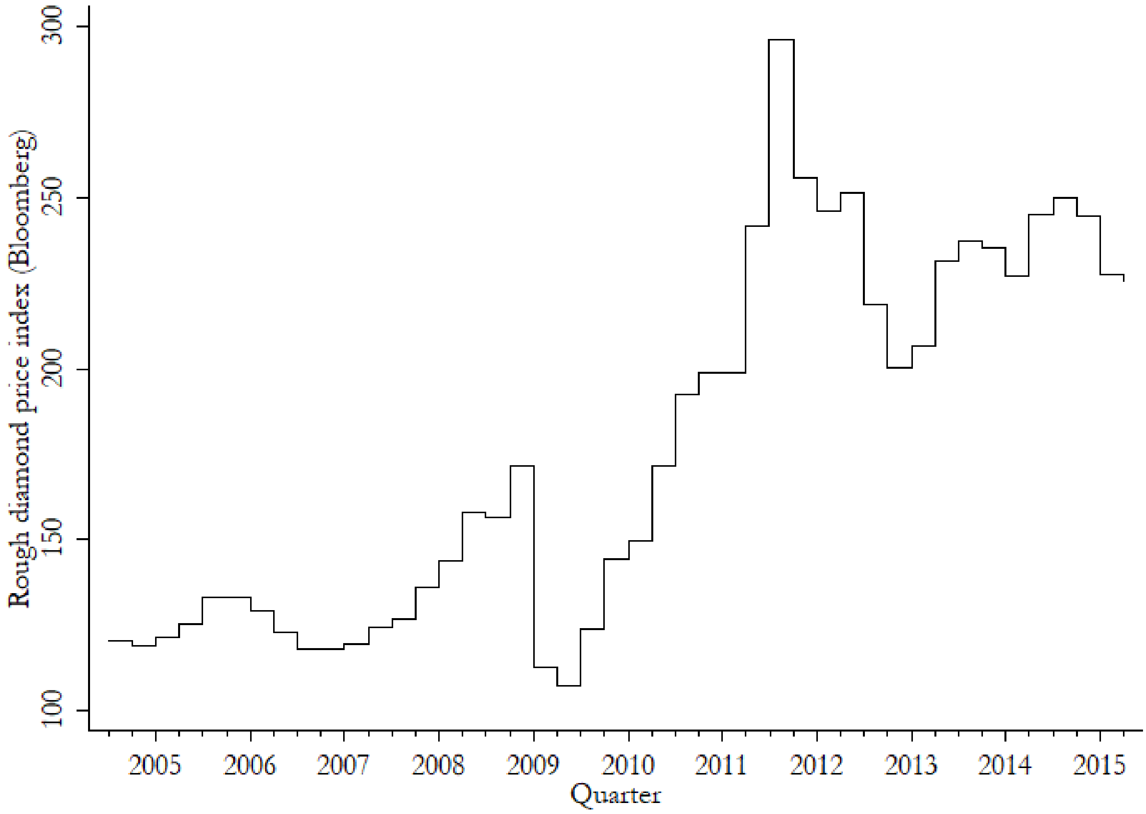


Table 1: Correlation between diamond propensity and existing measures of diamond occurrence

VARIABLES	(1) Primary diamond occurrence (DIADATA)	(2) Secondary diamond occurrence (DIADATA)	(3) Primary diamond occurrence (DIADATA)	(4) Secondary diamond occurrence (DIADATA)
Primary diamond propensity	0.124***		0.0625***	
	(0.0128)		(0.00187)	
Secondary diamond propensity		0.288***		0.352***
		(0.0657)		(0.0142)
Constant	0.437	2.978**	0.00672***	0.0115***
	(0.680)	(1.457)	(0.00169)	(0.00314)
Observations	52	52	10,682	10,682
R-squared	0.652	0.277	0.095	0.054
Unit of analysis	Country	Country	Grid-cell	Grid-cell

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Main results

VARIABLES	(1) Violent events ACLED	(2) Violent events UCDP	(3) Fatalities ACLED	(4) Fatalities UCDP
		Panel A: country level		
Primary diamond	0.0615	0.0780*	0.985*	0.628*
propensity * diamond price	(0.208)	(0.0417)	(0.509)	(0.373)
Secondary diamond	-0.00299	-0.00264**	-0.0348**	-0.0220*
propensity * diamond price	(0.00625)	(0.00130)	(0.0164)	(0.0126)
Observations	2,055	2,159	2,055	2,159
R-squared	0.578	0.519	0.393	0.374
Country FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
		Panel B: grid-cell level		
Primary diamond	-0.436	-0.156**	-4.464	-1.471
propensity * diamond price	(0.304)	(0.0784)	(2.815)	(1.105)
Secondary diamond	0.0373*	0.0118**	0.343*	0.105
propensity * diamond price	(0.0193)	(0.00560)	(0.203)	(0.0795)
Observations	427,280	448,644	427,280	448,644
R-squared	0.470	0.495	0.103	0.167
Country-Quarter FE	YES	YES	YES	YES
Grid-cell FE	YES	YES	YES	YES

Standard errors (clustered at the country level in Panel A and clustered at the grid-cell level in Panel B) in parentheses
* p<0.1 ** p<0.05 *** p<0.01

Table 3: diamond price and economic activity

VARIABLES	(1) Military exp. % GDP	(2) GDP per capita	(3) Nightlight	(4) Nightlight	(5) Nightlight	(6) Violent events UCDP	(7) Violent events UCDP	(8) Violent events UCDP
$PRIM_{i+0}$*diamond price			2.352***	2.776***	2.924***	-1.080	-1.328*	-1.569**
			(0.712)	(0.713)	(0.719)	(0.668)	(0.745)	(0.775)
SEC_{i+0}*diamond price			0.727***	0.702***	0.725***	1.442**	1.636**	1.943***
			(0.254)	(0.265)	(0.269)	(0.619)	(0.720)	(0.733)
$PRIM_{i+1}$*diamond price				1.110***	1.266***		-0.685*	-0.938**
				(0.367)	(0.387)		(0.368)	(0.415)
SEC_{i+1}*diamond price				0.665***	0.670**		0.185	0.522
				(0.242)	(0.263)		(0.439)	(0.442)
$PRIM_{i+2}$*diamond price					0.494			-0.902
					(0.328)			(0.573)
SEC_{i+2}*diamond price					0.320*			0.798
					(0.167)			(1.074)
Primary diamond propensity	0.166	-0.546						
* diamond price	(0.177)	(4.259)						
Secondary diamond propensity	-0.00651	0.0471						
* diamond price	(0.00669)	(0.125)						
Observations	423	499	95,994	95,994	95,994	448,644	448,644	448,644
R-squared	0.734	0.953	0.974	0.974	0.974	0.495	0.495	0.495
Unit of analysis	Country	Country	Grid-cell	Grid-cell	Grid-cell	Grid-cell	Grid-cell	Grid-cell
Time unit	Year	Year	Year	Year	Year	Quarter	Quarter	Quarter
Country FE	YES	YES	NO	NO	NO	NO	NO	NO
Year FE	YES	YES	NO	NO	NO	NO	NO	NO
Country-Year FE	NO	NO	YES	YES	YES	NO	NO	NO
Country-Quarter FE	NO	NO	NO	NO	NO	YES	YES	YES
Grid-cell FE	NO	NO	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: Different types of violence

VARIABLES	(1) UCDP armed conflict events	(2) UCDP non-state conflict events	(3) UCDP one-sided violence events	(4) UCDP armed conflict events	(5) UCDP non-state conflict events	(6) UCDP one-sided violence events
Primary diamond propensity	0.202	-0.0169	0.596	-0.585	0.187	-1.161**
* diamond price	(0.229)	(0.0678)	(0.432)	(0.435)	(0.155)	(0.483)
Secondary diamond propensity	-0.00837	-0.000444	-0.0176	0.0447	-0.0133	0.0865***
* diamond price	(0.00714)	(0.00239)	(0.0120)	(0.0314)	(0.0113)	(0.0333)
Observations	2,159	2,159	2,159	448,644	448,644	448,644
R-squared	0.610	0.347	0.302	0.563	0.087	0.170
Unit of analysis	Country	Country	Country	Grid-cell	Grid-cell	Grid-cell
Country FE	YES	YES	YES	NO	NO	NO
Quarter FE	YES	YES	YES	NO	NO	NO
Country-Quarter FE	NO	NO	NO	YES	YES	YES
Grid-cell FE	NO	NO	NO	YES	YES	YES

Clustered standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

Table 5: Endogeneity of diamond price

VARIABLES	(1) Violent events UCDP	(2) Violent events UCDP	(3) Violent events UCDP	(4) Violent events UCDP	(5) Violent events UCDP	(6) Violent events UCDP	(7) Violent events UCDP	(8) Violent events UCDP
Primary diamond propensity	0.0668*				-0.183*			
* diamond price	(0.0361)				(0.0938)			
Secondary diamond propensity	-0.00267*				0.0155**			
* diamond price	(0.00134)				(0.00736)			
Primary diamond propensity		0.123				-0.111		
* Brent oil price		(0.0779)				(0.108)		
Secondary diamond propensity		-0.00392*				0.00909		
* Brent oil price		(0.00233)				(0.00789)		
Primary diamond propensity			0.00359				-0.0116	
* gold price			(0.00515)				(0.00777)	
Secondary diamond propensity			-0.000153				0.000962*	
* gold price			(0.000160)				(0.000561)	
High soil quality				0.0444				0.00470
* diamond price				(0.0854)				(0.0100)
Moderate soil quality				-0.0173				-0.00399
* diamond price				(0.0571)				(0.00432)
Observations	2,033	2,262	2,262	2,159	406,812	470,008	470,008	448,518
R-squared	0.516	0.518	0.517	0.514	0.495	0.484	0.484	0.495
Unit of analysis	Country	Country	Country	Country	Grid-cell	Grid-cell	Grid-cell	Grid-cell
Sample	Excl. Botsw.; SA; Namibia	Full	Full	Full	Excl. Botsw.; SA; Namibia	Full	Full	Full
Country FE	YES	YES	YES	YES	NO	NO	NO	NO
Quarter FE	YES	YES	YES	YES	NO	NO	NO	NO
Country-Quarter FE	NO	NO	NO	NO	YES	YES	YES	YES
Grid-cell FE	NO	NO	NO	NO	YES	YES	YES	YES

Clustered standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

Table 6: Instrumenting for diamond price with Russian production volume

VARIABLES	(1) Violent events ACLED IV	(2) Violent events UCDP IV	(3) Fatalities ACLED IV	(4) Fatalities UCDP IV	(5) Violent events ACLED IV	(6) Violent events UCDP IV	(7) Fatalities ACLED IV	(8) Fatalities UCDP IV
Primary diamond propensity *	0.880**	0.511	5.668	4.068	-0.975	-0.542**	-14.52	-4.436
diamond price	(0.381)	(0.416)	(4.148)	(3.119)	(0.711)	(0.226)	(10.01)	(4.072)
Secondary diamond propensity *	-0.0284***	-0.0146	-0.176	-0.119	0.0495	0.0368**	1.048	0.356
diamond price	(0.0108)	(0.0113)	(0.114)	(0.0856)	(0.0462)	(0.0157)	(0.721)	(0.286)
Observations	2,055	2,159	2,055	2,159	427,280	448,644	427,280	448,644
R-squared	-0.083	-0.177	-0.091	-0.070	0.000	-0.000	-0.000	-0.000
Unit of analysis	Country	Country	Country	Country	Grid-cell	Grid-cell	Grid-cell	Grid-cell
Country FE	YES	YES	YES	YES	NO	NO	NO	NO
Quarter FE	YES	YES	YES	YES	NO	NO	NO	NO
Country-Quarter FE	NO	NO	NO	NO	YES	YES	YES	YES
Grid-cell FE	NO	NO	NO	NO	YES	YES	YES	YES

Clustered standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

Table 7: Investigating propensity measures

VARIABLES	(1) Violent events UCDP	(2) Violent events UCDP	(3) Violent events UCDP	(4) Violent events UCDP	(5) Violent events UCDP	(6) Violent events UCDP	(7) Violent events UCDP	(8) Violent events UCDP
Off archon kimberlite * diamond price	-0.02140				0.00738			
	(0.01553)				(0.00810)			
Upstream rivers * diamond price	0.00010				0.00003			
	0.00009				.			
Primary diamond propensity * diamond price		-0.01585				0.00652		
		(0.01179)				(0.01069)		
Secondary diamond propensity * diamond price			-0.00086				0.00766**	
			(0.00054)				(0.00360)	
Prim. diamond prop. binary * diamond price				0.0337				-0.0108
				(0.0266)				(0.00668)
Sec. diamond prop. binary * diamond price				-0.0802**				0.0144**
				(0.0356)				(0.00619)
Observations	2,159	2,159	2,159	2,159	448,644	448,644	448,644	448,644
R-squared	0.51413	0.51415	0.51609	0.521	0.49532	0.49532	0.49532	0.495
Unit of analysis	Country	Country	Country	Country	Grid-cell	Grid-cell	Grid-cell	Grid-cell
Country FE	YES	YES	YES	YES	NO	NO	NO	NO
Quarter FE	YES	YES	YES	YES	NO	NO	NO	NO
Country-Quarter FE	NO	NO	NO	NO	YES	YES	YES	YES
Grid-cell FE	NO	NO	NO	NO	YES	YES	YES	YES

Clustered standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

DIAMONDS: REBEL'S AND FARMER'S BEST FRIEND

Online Appendix: theoretical model and alternative econometric specifications

1. A simple model of lootable, labour-intensive resource production and violent conflict

This section presents a simple model that features production of a lootable, labour-intensive resource, looting, and rebellion. It borrows from Dal Bó and Dal Bó (2011) and Moretti (2011). The model produces several familiar results: an increase in the price of a labour-intensive resource decreases the intensity of violence, as the opportunity cost of violence increase (Dal Bó and Dal Bó 2011) and an increase in some exogenous flow of revenue to government increases violence by increasing the returns to overthrowing government (Besley and Persson 2009). Specific to this model is the following result: even though an increase in the price of a lootable, labour-intensive natural resource *decreases* the intensity of violence in the country as a whole - due to an opportunity cost effect -, it *increases* intensity of violence in the region where this resource is produced - due to a rapacity effect. Hence, a resource price increase *concentrates* violence in regions rich in a labour-intensive, lootable resource.

1.1. **Set-up**

Consider a country with a labour force normalized to size 1 and no capital. The country consists of two locations: region 1 "the capital", shorthand for any location strategic to the government and region 2, "the natural resource rich region", in which a lootable, labour-intensive resource can be produced.

Three sectors s in this country employ a share of total labour denoted by L_s:

1. A **mining** sector (subscript D), which produces a lootable, labour-intensive resource;
2. A **looting** sector (subscript L) which expropriates a share of the production of the mining sector;
3. A **rebellion** sector (subscript R), which fights the government to obtain some share of government revenue G.

The looting and rebellion sector are violent. The share of the labour force employed in violent occupations ($L_L + L_R$) is taken as an indicator for the overall intensity of violence in the country. Mining and looting must take place in natural resource-rich region 2. For now, assume rebellion can only take place in region 1. Then, L_R and L_L are indicators of the intensity of violence in regions 1 and 2 respectively.

A worker in location c in sector s earns wage $w_{s,c}$, equal to their marginal product. For now, assume that labour is perfectly mobile across sectors and locations, so that there is a single wage rate w.

The price of the lootable, labour-intensive resource is exogenously given world price p. Let demand for labour in the mining sector increase in p, and decrease in the cost of hiring miners, wage rate w.

$$L_D(w, p) \tag{1}$$

Let demand for labour in the looting sector be given by:

$$L_L(\mathrm{w}, p, A(L_D)), \text{ where } \frac{\partial L_L}{\partial A} > 0 \text{ and } \frac{\partial \mathrm{A}}{\partial L_D} > 0 \tag{2}$$

where A denotes the quantity of natural resource that can be looted. The demand for looters decreases in the wage rate, increases with the quantity of resource that can be looted and increases with p, the value of this resource. The quantity that can be looted increases with the number of workers in the mining sector, who produce the labour-intensive lootable resource. In Moretti's (2011) terms, an increase in the share of miners constitutes a positive shock to the productivity of the looting sector (Moretti 2011).

Labour demand in the rebellion sector decreases in the cost of hiring rebels w, and increases in the potential 'prize' of rebellion, exogenously given government revenue G. This parameter could be thought of as royalties earned from exploitation of a different, capital-intensive resource, produced using exclusively foreign capital, that the government can spend without being restrained by institutions (see (Besley and Persson 2009)).

$$L_R(w, G) \tag{3}$$

Equilibrium in the labour market requires:

$$L_D(\mathrm{w}, p) + L_L\big(\mathrm{w}, p, A(L_D)\big) + L_R(\mathrm{w}, G) = 1 \tag{4}$$

1.2. **Derivation of results**

This model can be used to examine the effect of an increase in the price of the lootable, labour-intensive resource on the equilibrium wage, the intensity of violence in the country overall, and the intensity of violence in the resource-rich region.

Results 1 and 2 are familiar results, also obtained by Dal Bó and Dal Bó (2011): an increase in the price of a labour-intensive resource decreases the intensity of violence, as the opportunity cost of violence increase. Result 3 is specific to this model: although overall intensity of violence decreases, violence *concentrates* in the natural resource rich region, due to a rapacity effect. Result 4 is again familiar: it is also obtained by Besley and Persson (2009): an increase in some exogenous flow of revenue to government increases violence by increasing the returns to overthrowing government.

RESULT 1. The equilibrium wage increases with an increase in the price of the lootable, labour-intensive natural resource.

DERIVATION. Taking the total derivative of the equilibrium condition with respect to w gives:

$$\frac{dw}{dp} = \frac{-\frac{\partial L_L}{\partial p} - \frac{\partial L_D}{\partial p}(1+\gamma)}{\frac{\partial L_R}{\partial w} + \frac{\partial L_L}{\partial w} + \frac{\partial L_D}{\partial w}(1+\gamma)} > 0 \tag{5}$$

where $\gamma = \frac{\partial L_L}{\partial A}\frac{\partial A}{\partial L_D} > 0$ reflects the positive spill-over from mining to looting. Expression (5) is positive, as both the numerator and denominator are negative, implying that the equilibrium wage rate increases with the resource price.

Intuition behind this result is as follows. As the price of the lootable, labour-intensive resource increases, both mining and looting become more productive: the resource being mined and looted is now more valuable. This increases demand for miners and looters, and the wage rate in the natural resource-rich region increases. The increase in wages in the natural-resource rich increases the opportunity cost of rebellion, and induces rebels previously employed in the capital, to move to the natural resource-rich region to become miners and looters. The increase in the number of miners has spill-over effects on the productivity of looters: not only is the resource being looted more valuable, the increase in the number of miners implies that there is now more to loot. This again increases the demand for looters and the wage rate in the natural-resource rich region. Rebels will continue to move from the capital to the natural-resource rich region, decreasing the supply of labour in the former, and increasing the supply of labour in the latter, until wages in both regions again equal at a higher rate than prior to the resource price increase, and equilibrium is restored.

From this intuition, it is straightforward to see that the number of miners and looters increases, and the number of rebels decreases with an increase in the price of the lootable, labour-intensive resource. As employment in mining - the only non-violent profession - increases, it follows that the number of workers employed in the remaining violent professions combined must decrease. The next two results follow.

RESULT 2. The share of the workforce employed in violent professions, and thus the intensity of violence in the country overall, *decreases* with an increase in the price of the lootable, labour-intensive resource.

DERIVATION. From labour demand for miners, we can obtain: $\frac{dL_D}{dp} = \frac{\partial L_D}{\partial w}\frac{dw}{dp} + \frac{\partial L_D}{\partial p}$. For a horizontal or linear upward sloping labour supply curve, this expression is positive.[1] In equilibrium, any increase in demand for labour in the mining sector must be mirrored by a decrease in labour demand in the remaining, violent, professions. Specifically:

$$\frac{dL_L + dL_R}{dp} = -\left(\frac{\partial L_D}{\partial w}\frac{dw}{dp} + \frac{\partial L_D}{\partial p}\right) < 0 \qquad (6)$$

RESULT 3. The share of the workforce employed in the looting sector, and thus the intensity of violence in the resource-rich region, *increases* with an increase in the price of the lootable, labour-intensive resource.

DERIVATION. From labour demand for looters, we can obtain:

$$\frac{dL_L}{dp} = \frac{\partial L_L}{\partial w}\frac{dw}{dp} + \frac{\partial L_L}{\partial p} + \gamma\left(\frac{\partial L_D}{\partial w}\frac{dw}{dp} + \frac{\partial L_D}{\partial p}\right) > 0$$

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[1] If the labour supply curve were back-bending, this would not necessarily be the case.

(7)

which is positive for a horizontal or linear upward sloping labour supply curve, $\frac{dL_D}{dp} > 0$ and $\gamma > 0$.

RESULT 4. The share of the workforce employed in violent professions increases with an increase in government revenue.

DERIVATION. $\frac{\partial L_R}{\partial G} > 0$ by the definition of the labour demand curve for rebellion and $\frac{dw}{dG} > 0$. The equilibrium wage rate increases with an increase in government revenue. This draws labour away from the mining sector: $\frac{\partial L_D}{\partial G} = \frac{\partial L_D}{\partial w}\frac{dw}{dG} < 0$. By the equilibrium equation for the labour market:

$$\frac{\partial L_L + L_R}{\partial G} = -\frac{\partial L_D}{\partial G} > 0$$

(8)

An increase in government revenue increases the productivity of rebels and increases the wage rate in the capital. This draws labour away from the mining and looting sectors in region 2 toward region 1, decreasing labour supply in the former and increasing it in the latter, until the wage rates in both regions again equal. Since the number of miners decreases, the number of workers employed the remaining, violent sectors must increase. Note that this result does not unequivocally hold if we allow the government some capacity to defend itself (see section 2.3 of this Appendix).

2. Extensions to the theoretical model

Several assumptions in the simple theoretical model can be relaxed without qualitatively affecting the above predictions. These include allowing rebellion in the resource-rich region as well as in the capital[2], restricting mobility between the two regions and restricting mobility between 'peaceful' and violent professions. This section also explores the case in which the share of looters constitutes a negative shock to productivity in the mining sector and a scenario adding a government which can hire labour in region 1 to defend itself. Results 1-3 are reproduced, although this requires some additional assumptions regarding spill-overs.

2.1. **Restricting mobility across regions**

Restricting mobility across regions does not qualitatively affect the main results.

A worker in sector s in region j earns $w_{s,j}$. Assume that there is only one type of labour which is perfectly mobile across sectors so that $w_{D,2} = w_{L,2} = w_2$. Following Moretti (2011), utility of worker i employed in location c in sector s is: $U_{is,c} = w_{s,c} + e_{i,c}$, where $e_{i,1} - e_{i,2} \sim U[-\theta, \theta]$ represents worker i's relative preferences for location 1 over location 2 (Moretti 2011). In equilibrium, the marginal worker is indifferent between both locations, which implies an upward sloping local labour supply curve in each location, the slope of which depends on θ. If $\theta = 0$, labour is perfectly mobile across locations and there is a single wage rate w. For example, the labour supply curve for region 1 is given by:

$$w_1 = w_2 + \theta(L_R - L_D - L_L) \tag{9}$$

[2] Although this version of the model can only support an increase in violence in region 2 relative to region 1, not an absolute increase in violence in region 2.

If $(L_R - L_D - L_L)$ is negative, the marginal worker in region 1 has an idiosyncratic preference for this region, accepting a lower wage rate in region 1 than in region 2, without being induced to move.

Note that using (9) we can write L_R as a function of w_2, L_D, L_L and G. Equilibrium in the labour market now requires:

$$L_D(\mathrm{w}_2, p) + L_L\big(\mathrm{w}_2, p, A(L_D)\big) + L_R(\mathrm{w}_2, L_D, L_L, G) = 1$$

Taking the total derivative with respect to w_2 gives:

$$\frac{dw_2}{dp} = \frac{-\dfrac{\partial L_L}{\partial p} - \dfrac{\partial L_R}{\partial L_L}\dfrac{\partial L_L}{\partial p} - \dfrac{\partial L_D}{\partial p}(1+\gamma) - \dfrac{\partial L_R}{\partial L_D}\dfrac{\partial L_D}{\partial p}(1+\gamma)}{\dfrac{\partial L_R}{\partial w_2} + \dfrac{\partial L_L}{\partial w_2} + \dfrac{\partial L_R}{\partial L_L}\dfrac{\partial L_L}{\partial w_2} + \dfrac{\partial L_D}{\partial w_2}(1+\gamma) + \dfrac{\partial L_R}{\partial L_D}\dfrac{\partial L_D}{\partial w_2}(1+\gamma)} > 0$$

which can be shown to be positive as both the numerator and denominator are negative. To see this, note that:

$$\frac{\partial L_R}{\partial L_D} = \frac{1}{1 - \dfrac{\partial L_R}{\partial w_1}\dfrac{\partial w_1}{\partial L_R}}\frac{\partial L_R}{\partial w_1}\frac{\partial w_1}{\partial L_D} = \frac{-\theta}{1 - \dfrac{\partial L_R}{\partial w_1}\theta}\frac{\partial L_R}{\partial w_1} = \frac{\partial L_R}{\partial L_L}$$

which is positive as θ is positive and $\frac{\partial L_R}{\partial w_1}$ is negative.

Expressions (6) and (7) remain unchanged in essentials, although expressions now only hold weakly. Results 1-3 are reproduced.

2.2. Negative externalities in the mining sector

So far, an increase in the share of miners has been modelled as a positive shock to productivity in the looting sector. One might argue that instead, an increase in the share of looters is a negative shock to productivity in the mining sector, as the unlooted quantity produced remaining to miners is lower the more looters exist. Alternatively, one may think that a larger number of looters diverts miners' energy to self-defence, constituting a negative shock to productivity. In this case, obtaining the same results as presented in the main text requires additional assumptions regarding the size of this negative externality.

Modelling this negative externality, let equilibrium in the labour market require:

$$L_D\big(\mathrm{w}, p, A_D(L_L)\big) + L_L(\mathrm{w}, p) + L_R(\mathrm{w}, G) = 1$$

with $\frac{\partial L_D}{\partial A_D} < 0$ and $\frac{\partial A_D}{\partial L_L} > 0$. That is, demand for labour in the mining sector decreases the larger the quantity being looted, and the quantity being looted is larger the larger the share of labour working in the looting sector.

Taking the total derivative with respect to w gives:

$$\frac{dw}{dp} = \frac{-\frac{\partial L_D}{\partial p} - \frac{\partial L_L}{\partial p}(1 + \varphi)}{\frac{\partial L_R}{\partial w} + \frac{\partial L_{D2}}{\partial w} + \frac{\partial L_L}{\partial w}(1 + \varphi)} \tag{10}$$

where $\varphi = \frac{\partial L_D}{\partial A_D}\frac{\partial A_D}{\partial L_L} < 0$ reflects the negative spill-overs to the mining sector from looting. If negative spill-overs are small so that $-\varphi < 1$, expression (10) is positive, implying the equilibrium wage rate increases with the price of the lootable, labour-intensive resource.

However, unlike before, there exists a range of values for which the equilibrium wage *decreases* with the resource price.[3] In this case, an increase in the price of the resource induces an influx of workers into the looting sector that is so large that looters are 'killing the goose with the golden eggs', and the equilibrium wage declines.

We can further obtain:

$$\frac{dL_L + dL_R}{dp} = -\left[\frac{\partial L_D}{\partial w}\frac{dw}{dp} + \frac{\partial L_D}{\partial p} + \varphi\left(\frac{\partial L_L}{\partial w}\frac{dw}{dp} + \frac{\partial L_L}{\partial p}\right)\right] \tag{11}$$

$$\frac{dL_L}{dp} = \frac{\partial L_L}{\partial w}\frac{dw}{dp} + \frac{\partial L_L}{\partial p} > 0 \tag{12}$$

Expression (12) is positive if $\frac{dw}{dp} > 0$. Violence in the resource-rich region increases with an increase in the resource price. The sign of expression (11) depends on the size of negative spill-overs from the looting sector to the mining sector. If spill-overs are small such $-\varphi < \frac{\frac{\partial L_D}{\partial w}\frac{dw}{dp} + \frac{\partial L_D}{\partial p}}{\frac{\partial L_L}{\partial w}\frac{dw}{dp} + \frac{\partial L_L}{\partial p}}$, expression (11) is negative, and the overall intensity of violence decreases with an increase in the price of a lootable, labour-intensive resource, as before.

2.3. **Adding government defence**

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[3] Specifically, if $\frac{\partial L_L}{\partial p}$ is large in the sense that: $-\varphi\frac{\partial L_L}{\partial p} > \frac{\partial L_L}{\partial p} + \frac{\partial L_D}{\partial p}$ and $\frac{\partial L_L}{\partial w}$ is small in the sense that $-\varphi\frac{\partial L_L}{\partial w} < \frac{\partial L_D}{\partial w} + \frac{\partial L_R}{\partial w} + \frac{\partial L_L}{\partial w}$, or if $\frac{\partial L_L}{\partial p}$ is small and $\frac{\partial L_L}{\partial w}$ is large. Note that expression (10) is positive if $\varphi < -1$ or if $\frac{\partial L_L}{\partial p}$ and $\frac{\partial L_L}{\partial w}$ are both either small or large.

Now, introduce a government, that can hire labour to defend itself. Let $L_G(w, G)$ be government demand for labour, which depends negatively on the wage rate and positively on the amount of government revenue. In addition, let demand for labour in the rebellion sector be:

$$L_R(\mathrm{w}, G, C(L_G)), \text{ where } \frac{\partial L_R}{\partial C}<0 \text{ and } \frac{\partial C}{\partial L_G} > 0$$

An increase in the share of labour employed as defenders by government constitutes a negative shock to the productivity of rebels. Intuitively, the same number of rebels would obtain a smaller share of G if the number of defenders is higher. The size of this negative shock increases with the share of labour employed in defence.

Equilibrium in the labour market now requires:

$$L_D(\mathrm{w}, p) + L_L(\mathrm{w}, p, A(L_D)) + L_R(\mathrm{w}, G, C(L_G)) + L_G(w, G) = 1 \tag{13}$$

This generates the somewhat counter-intuitive possibility for the equilibrium wage to decrease with an increase in the price of the lootable, labour-intensive natural resource. To see this, take the total derivative of (13) with respect to w:

$$\frac{dw}{dp} = \frac{-\frac{\partial L_L}{\partial p} - \frac{\partial L_D}{\partial p}(1+\gamma)}{\frac{\partial L_R}{\partial w} + \frac{\partial L_L}{\partial w} + \frac{\partial L_D}{\partial w}(1+\gamma) + \frac{\partial L_G}{\partial w}(1+\mu)} \tag{14}$$

where $\mu = \frac{\partial L_R}{\partial C}\frac{\partial C}{\partial L_G} < 0$ reflects the negative spill-overs between the government defence and rebel sectors. Expression (14) can be negative, if $-\mu$ is so large as the make the denominator positive.

Expressions (6) and (7) are unchanged. Unless μ is so large that $\frac{dw}{dp} < 0$, the qualitative conclusion that violence in the resource-rich area increases, but overall violence decreases with an increase in the resource price is upheld.

In this set-up, a positive shock to G does no longer unambiguously result in an increase in share of workers employed in violent professions. In this case, $\frac{\partial L_G}{\partial G} > 0$, but the sign of $\frac{\partial L_R}{\partial G}$ depends on the size of the negative spill-overs between the government defence and rebel sector. Intuitively, if spill-overs are large, the number of rebels may *decrease* with an increase in government revenue, as the increased returns to rebellion due to increased government revenue are outweighed by decreased returns to rebellion due to increased government capacity to defend itself. If this decrease in the number of rebels is larger than the increase in the number of government defence forces, the overall level of violence in the country decreases.

2.4. **Allowing rebellion in resource-rich regions**

Allowing rebellion to take place in resource-rich region 2 as well as in capital region 1 leaves unaffected the prediction in the main text regarding the overall intensity of violence. In this scenario, an increase in the price of the lootable, labour-intensive resource draws labour away from the rebellion sector in both areas, toward the looting and mining sectors. As at least some rebels become miners, the overall level of violence declines.

Predictions regarding the *absolute* intensity of violence in the resource-rich region *are* affected. The intensity of violence in region 2 is now given by the share of labour employed as either looters or rebels in this region. Whether the absolute number of workers employed in violent professions in region 2 increases or decreases, depends on the relative growth of the looting and decline of the rebellion sector in this region.

However, as long as the marginal returns to labour in the rebellion sector in region 2 are similarly or more strongly decreasing, compared to the marginal returns to labour in the rebellion sector in region 1, violence in region 2 still increases *relative* to violence in region 1. Region 1, the capital, is a location that is strategic to the government, so by definition marginal returns labour in the rebellion sector in this region are less steeply decreasing compared to other regions. With an increase in resource price the equilibrium wage, the rebellion sector in region 1 must release more labour for marginal turns to labour to equal the new equilibrium wage rate compared to the rebellion sector in region 2. Coupled with an increase in employment in the looting sector in the latter region, this implies that violence in region 2 increases *relative* to violence in region 1.

2.5. **Restricting mobility between 'peaceful' and violent professions**

Finally, it is possible to restrict mobility between 'peaceful' and violent professions without qualitatively affecting predictions. Mobility would be restricted if there are barriers either to recruiting individuals into an armed group, or to demobilization from an armed group. In the model, this introduces a 'wedge' between the marginal productivity, and thus the wage rate, of miners and those in violent professions. This does not affect predictions regarding the effect of the resource price increase on employment in the looting sector. However, it makes the effect of a resource price increase on overall violence less pronounced than before. This is easy to see if we imagine no mobility at all between violent and 'peaceful' sectors: in this case, the total share of labour in violent professions is fixed, but some rebels move to region 2 to become looters increasing intensity of violence in this region. Unless mobility is completely restricted, qualitative predictions from the main text remain unchanged.

3. Diamond propensity: false positives and false negatives

Investigating the overlap between diamond propensity and DIADATA, Table A1 displays 'false positives' (instances where the diamond propensity predicts potential for diamonds in a country, but DIADATA does not record any) and 'false negatives'. The number of false positives and negatives is small, between 5.7 and 17.3 % of all countries. As expected, these numbers are higher for secondary than for primary diamonds. Looking at specific countries, there is some logic to false positives and negatives: many can be considered 'borderline' cases. In several 'false positives', the DIADATA codebook indicates prospecting or exploration for primary diamonds, or some occurrences of secondary diamonds that could not be geo-located (Gilmore et al. 2005). Among 'false negatives', there is prospecting but no known production, or sources disagree as to the potential for or origin of secondary diamonds.

Table A1: Diamond propensity false positives and negatives

	Primary diamond propensity		Secondary diamond propensity	
	Number (%)	Countries	Number (%)	Countries
'False positives'	4 (7.7%)	Ghana†, Kenya*, Uganda*, Zambia†	9 (17.3%)	Botswana*, Burundi, Kenya*, Mauritania†, Rwanda, Senegal*, Sudan, Swaziland†, Uganda*
'False negatives	3 (5.7%)	Burkina Faso‡, Mozambique‡, Lesotho	6 (11.5%)	Algeria°, Cameroon°, Chad°, Congo°, Lesotho, Nigeria°

* Secondary diamonds reported found
† Exploration or prospecting for primary diamonds
‡ No known production
° Sources differ, or some doubt regarding origin diamonds
(Gilmore et al. 2005)

4. Data sources for control variables

Table A2: data sources for control variables

Variable	Source
Nightlight	DMSP – OLS Night-time lights time series.
Distance to capital	Author calculations and CShapes dataset (Weidmann, Kuse, and Gleditsch 2010)
Excluded	Prio-Grid v2.0, GeoEPR/EPR 2014 (Vogt et al. 2015)
Onset	UCDP armed conflict dataset, UCDP non-state conflict dataset, UCDP one-sided violence dataset. Available at: http://ucdp.uu.se/downloads/
Russian export volume	Kimberley Process Statistics, available at: https://kimberleyprocessstatistics.org/public_statistics
Brent oil price Gold price Platinum price	Bloomberg
Iron ore price	World Bank Global Economic Monitor Commodities, available at: http://databank.worldbank.org/data/reports.aspx?source=global-economic-monitor-commodities
Gold deposits Platinum deposits Iron ore deposits	Mineral Resources Data System (MRDS), available at: https://mrdata.usgs.gov/mrds/
Giant oil deposits	Horn (2014). Available at: https://worldmap.harvard.edu/data/geonode:giant_oil_and_gas_fields_of_the_world_co_yxz
Soil suitability to agriculture	Harmonized world soil database v1.2, available at: http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/
Land use	Prio-Grid v2.0, ISAM-HYDE historical land use dataset (Meiyappan and Jain 2012)
Mountain	Prio-Grid v2.0 UNEP Mountain Watch Report (Blyth et al. 2002)

5. Descriptive statistics

Table A3: Descriptive statistics

Variable	N	Mean	SD	Min	Max
Country-quarter					
Violent events ACLED	2158	20.925	63.254	0.000	853.000
Violent events UCDP	2262	6.042	18.426	0.000	201.000
Fatalities ACLED	2158	73.930	270.902	0.000	3555.000
Fatalities UCDP	2262	52.179	207.352	0.000	4242.000
UCDP armed conflict events	2262	3.244	11.022	0.000	110.000
UCDP non-state conflict events	2262	0.911	4.063	0.000	68.000
UCDP one-sided violence events	2262	1.874	8.537	0.000	172.000
ACLED armed conflict events	2158	6.938	24.698	0.000	350.000
ACLED non-state conflict events	2158	2.733	11.919	0.000	157.000
ACLED one-sided violence events	2158	9.146	24.985	0.000	371.000
Rough diamond price index	2159	1.791	0.538	1.075	2.959
Primary diamond propensity	2262	15.620	51.195	0.000	284.000
Secondary diamond propensity	2262	947.630	2019.113	0.000	10808.91
Country-year					
Nightlight	462	1.113	0.319	1.001	3.662
UCDP armed conflict onset	514	0.056	0.231	0.000	1.000
UCDP any conflict onset	465	0.232	0.423	0.000	1.000
Grid-cell-quarter					
Violent events ACLED	448645	0.095	1.750	0.000	359.000
Violent events UCDP	470009	0.021	0.500	0.000	76.000
Fatalities ACLED	448645	0.334	8.746	0.000	2083.000
Fatalities UCDP	470009	0.184	5.953	0.000	1032.000
UCDP armed conflict events	470009	0.011	0.381	0.000	76.000
UCDP non-state conflict events	470009	0.003	0.129	0.000	37.000
UCDP one-sided violence events	470009	0.007	0.191	0.000	43.000
ACLED armed conflict events	448645	0.031	0.878	0.000	205.000
ACLED non-state conflict events	448645	0.012	0.285	0.000	60.000
ACLED one-sided violence events	448645	0.042	0.612	0.000	84.000
Primary diamond propensity (100s)	470009	0.001	0.009	0.000	0.360
Secondary diamond propensity (100s)	470009	4.562	21.613	0.000	410.648
Grid-cell-year					
Nightlight	95994	1.063	0.299	1.000	8.905

6. Investigating robustness of main empirical results

6.1. Conflict onset, incidence and intensity

It has been argued that violent conflict onset on the one hand, and conflict incidence and intensity on the other hand, are governed by different processes: conflict onset requires overcoming a collective action problem among rebels, whereas continued conflict incidence or increasing conflict intensity does not (Ciccone 2011; Bazzi and Blattman 2014).

Table A4, columns 1 to 4 show that main results at the country-level are driven by intensity of violence rather than by conflict onset or incidence. Both diamond interaction terms are not significantly related to onset of armed conflict (column 1) or onset of any type of conflict (column 2). Neither interaction term is related to conflict incidence at the country level, an indicator equalling one if a country experienced any conflict event in a given year according to UCDP (column 3).[4] The main results at the country level are driven by the intensive margin, or conflict intensity: the interaction term including secondary diamond propensity is significantly related to the number of UCDP conflict events, restricting the sample to countries where at least one such event has taken place (column 4). Results involving primary diamond propensity do not survive this restriction of the sample.

At the grid-cell level, what constitutes conflict onset is less clear-cut: there may be a collective action problem to overcome in the first grid-cell to enter into conflict, but expanding violence to other grid-cells may not involve such problems. PRIO-GRID v1.01 provides an indicator for

[4] Note that UCDP only records conflict events for a particular country and year if more than 25 battle-related deaths resulted from such events.

Table A4: Onset, incidence and intensity

VARIABLES	(1) UCDP armed conflict onset	(2) UCDP conflict onset	(3) UCDP events>0	(4) # of UCDP events if >0	(5) UCDP events>0	(6) # if UCDP events if >0
Primary diamond propensity	0.000100	0.00156	0.00088	0.232	-0.0498*	-336.6***
* diamond price	(0.001321)	(0.00143)	(0.00124)	(0.204)	(0.0278)	(123.9)
Secondary diamond propensity	-0.000006	-0.00004	-0.00003	-0.00812**	0.00367*	2.230
* diamond price	(0.000040)	(0.00004)	(0.00003)	(0.00328)	(0.00198)	(2.372)
Observations	514	465	2,159	590	448,644	3,133
R-squared	0.187213	0.60995	0.62763	0.455	0.217	0.723
Unit of analysis	Country	Country	Country	Country	Grid-cell	Grid-cell
Country FE	YES	YES	YES	YES	NO	NO
Year FE	YES	YES	NO	NO	NO	NO
Quarter FE	NO	NO	YES	YES	NO	NO
Country-Quarter FE	NO	NO	NO	NO	YES	YES
Grid-cell FE	NO	NO	NO	NO	YES	YES

Clustered standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

conflict onset equalling one if the first event of a particular conflict took place in a grid-cell. However, this variable is only available up to 2008 and therefore of little use to the present analysis.

Results using UCDP violent events suggest that main results at the grid-cell level are driven by increased conflict incidence: an increase in the probability of a cell experiencing more than zero conflict events (column 5). The point estimate suggests that the interaction term between secondary diamond propensity and diamond price is positively related to conflict intensity at the grid-cell level (column 6), but this result is not statistically significant.

6.2. Price shocks, conflict onset, and changes in conflict intensity

This section investigates the effect of diamond price shocks – defined here as the percentage change in the diamond price – on changes in violent conflict – particularly conflict onset and changes in conflict intensity. As such, it addresses a conceptually different question compared to the previous section and the main text.

Table A5 suggests that unlike diamond price levels, diamond price shocks affect the likelihood of armed conflict onset. A positive shock to the diamond price is associated with a higher likelihood of armed conflict onset in countries with primary diamond propensity, but a lower likelihood of armed conflict onset in countries with secondary diamond propensity (column 1). These results are consistent with the 'prize' of government mechanism and the opportunity cost mechanism respectively. Results are statistically significant when considering armed conflict onset only. Coefficients carry a similar sign but are not statistically significant when considering the start of a non-state armed conflict or one-sided violence as a conflict onset as well (column 2).

Column 3 investigates the impact of a diamond price shock on the level of conflict fatalities – analogous to the specification employed by Bazzi and Blattman (Bazzi and Blattman 2014). This does not produce statistically significant results. Restricting the sample to countries that experience more than zero conflict fatalities in consecutive years however, a positive diamond price shock is associated with a faster rate of increase in conflict-related fatalities in countries geologically likely to have primary diamonds (column 4).

Table A5: Price shocks, conflict onset and conflict intensity

VARIABLES	(1) UCDP armed conflict onset	(2) UCDP conflict onset	(3) Fatalities UCDP	(4) % change fatalities UCDP
Primary diamond propensity *	0.00788***	0.00335	13.51751	70.84125**
% change diamond price	(0.003)	(0.004)	(11.601)	(31.068)
Secondary diamond propensity *	-0.00023***	-0.00009	-0.36500	-0.47743
% change diamond price	(0.000)	(0.000)	(0.318)	(0.292)
Observations	462	413	462	169
R-squared	0.236	0.620	0.544	0.174
Unit of analysis	Country	Country	Country	Country
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Clustered standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

6.3. **Additional controls**

Columns 1 and 5 of Table A6, include control variables capturing the presence of other resources. These include oil, which is found to be related to conflict in numerous studies (Dube and Vargas 2013; Besley and Persson 2009; Bell and Wolford 2015; Lei and Michaels 2014) and gold, platinum and iron, which are also found on-archon and occur in primary and secondary deposits (Clifford 1966). The number of deposits present is interacted with the resource price. Column 1 suggests the oil price is related to an increase in the number of violent events in countries with giant oil deposits. Main results at country and grid level are robust to controlling for other resources. Main results are also robust to controlling for the number of excluded groups present in a country (column 2) or grid-cell (column 5).

Table A6: Additional controls

VARIABLES	(1) Violent events UCDP	(2) Violent events UCDP	(3) Violent events UCDP	(4) Violent events UCDP	(5) Violent events UCDP	(6) Violent events UCDP
Primary diamond propensity	0.0965**	0.0796*	0.0812*	-0.159**	-0.123	-0.173**
* diamond price	(0.0374)	(0.0457)	(0.0417)	(0.0788)	(0.0769)	(0.0822)
Secondary diamond propensity	-0.00326**	-0.00258*	-0.00296**	0.0117**	0.0106*	0.00548
* diamond price	(0.00125)	(0.00137)	(0.00128)	(0.00563)	(0.00553)	(0.00661)
Primary gold	0.948			0.000442		
* gold price	(1.148)			(0.0180)		
Secondary gold	-2.811			-0.0156		
* gold price	(5.992)			(0.100)		
Primary platinum	4.676			-0.156		
* platinum price	(9.271)			(0.114)		
Secondary platinum	70.93			-0.103		
* platinum price	(63.64)			(0.114)		
Primary iron	39.08			1.430		
* iron price	(64.44)			(1.714)		
Secondary iron	-78.55			0.773		
* iron price	(48.06)			(1.222)		
Giant oil deposits	156.4**			-8.587		
* Brent oil price	(69.60)			(6.293)		
# excluded groups		1.177			0.0229***	
		(1.731)			(0.00706)	
Agriculture (75th %ile)			-0.0768			0.0474
* quarter			(0.267)			(0.0323)
Urban (75th %ile)			0.242			0.146***
* quarter			(0.232)			(0.0320)
Water (75th %ile)			-0.165			0.0261
* quarter			(0.165)			(0.0352)
Mountain (75th %ile)			-0.334*			-0.0129
* quarter			(0.167)			(0.0222)
Observations	1,865	1,739	2,058	421,680	298,527	432,516
R-squared	0.562	0.543	0.534	0.503	0.221	0.498
Unit of analysis	Country	Country	Country	Grid-cell	Grid-cell	Grid-cell
Country FE	YES	YES	YES	NO	NO	NO
Quarter FE	YES	YES	YES	NO	NO	NO
Country-Quarter FE	NO	NO	NO	YES	YES	YES
Grid-cell FE	NO	NO	NO	YES	YES	YES

Clustered standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

Lastly, I consider the possibility that primary and secondary diamond propensity are related to particular land-use patterns, and that countries or grid-cells with different types of land-use experience different trends in the intensity of violence that are correlated with the diamond price. I construct a set of indicators equalling one if a country or grid-cell is in the 75th percentile with regard to use of land for (a) agriculture; (b) urban spaces; (c) water; and (d) mountains. Inclusion of land-use specific time trends does not affect results at the country level (column 3 of Table A6). However, results at the grid-cell level are affected: the coefficient on the interaction term between secondary diamond propensity and diamond price halves in size and is no longer statistically significant (column 6). The time trend for urban grid-cells is strongly and positively related to conflict intensity. A simple correlation suggests that grid-cells with higher secondary diamond propensity indeed contain a greater share of land-use classified as 'urban'. To the extent that increased population in a grid-cell, and thus increased urban build-up, is a mechanism connecting the diamond price and intensity of violence in areas with secondary diamond propensity, this loss of significance may be expected. However, it is possible that the main results for secondary diamond propensity at the grid-cell level are partially driven by differing trends in violence in urban areas.

6.4. **Alternative econometric specifications**

Table A7 displays a further set of robustness checks. At the country level, results are unaffected when including country-specific time trends rather than country and quarter fixed effects (column 1). Results obtained when including interaction terms between diamond propensity and the first lag of diamond price are similar to the main results at both country (column 2) and grid-cell level (column 5). Re-estimating the main models using yearly or monthly data also gives results similar to the main results (not shown).

So far results presented have been obtained using OLS. However, the events data used could be considered count data, which is overdispersed and has an excess of zeros. Hilbe (2011) suggests a

Hurdle model, which in this case implies estimating one fixed effects logit regression (clogit) with a dummy for the presence of any violent event as a dependent variable, and one negative binomial regression[5], with the number of violent events for observations with at least one such event as a dependent variable (Hilbe 2011). Producing equivalent results at the grid-cell level is extremely computationally intensive, due to country-quarter and grid-cell fixed effects. To make computation manageable, I demean data using averages by quarter for the logit regression, and averages by grid-cell for the negative binomial regression[6]. Results in columns 3, 4, 6 and 7 are very similar to those obtained in Table A4.

Table A8 displays a final set of robustness checks. Results are robust to multi-way clustering of standard errors (columns 1 and 2). They are sensitive to clustering the standard errors at the country level (column 3). Results do hold when estimating standard errors at the grid level with a spatial HAC correction, allowing for cross-sectional spatial correlation up to 500 kilometres and imposing no restraint on location-specific temporal serial correlation (column 4) (Conley 1999; Hsiang, Meng, and Cane 2011).

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[5] It is worth noting that it has not been theoretically established that a negative binomial model gives consistent estimates when including a set of dummy variables by way of fixed effects. However, an empirical investigation into this by Allison and Waterman (2002) suggests that these estimates are unbiased (Allison and Waterman 2002).

[6] Again, is has not been established theoretically that this approach results in consistent estimates. Paul Allison does suggest however, that he sees no reason why such estimates would suffer from incidental parameter bias. See https://statisticalhorizons.com/fe-nbreg, accessed 17 November 2011.

Table A7: Alternative econometric specifications

VARIABLES	(1) UCDP events hdfe	(2) UCDP events hdfe	(3) UCDP >0 events clogit	(4) # if UCDP events if >0 nbreg	(5) UCDP events hdfe	(6) UCDP >0 events clogit (within)	(7) # if UCDP events if >0 nbreg (within)
Primary diamond propensity *	0.111*		0.000603	-0.00620		-13.52	-1.468
diamond price	(0.0651)		(0.0185)	(0.0108)		(36.35)	(2.213)
Secondary diamond propensity *	-0.00345*		-0.000187	-0.000233**		1.091**	0.0634
diamond price	(0.00188)		(0.000321)	(0.000107)		(0.531)	(0.0473)
Primary diamond propensity *		0.0605*			-0.165*		
diamond price (t-1)		(0.0327)			(0.0854)		
Secondary diamond propensity *		-0.00218*			0.0122**		
diamond price (t-1)		(0.00111)			(0.00609)		
Constant	-28.47			1.927***			3.124***
	(18.78)			(0.455)			(0.0781)
Observations	2,159	2,107	1,193	592	437,962	46,914	3,828
R-squared	0.540	0.522			0.489		
Unit of analysis	Country	Country	Country	Country	Grid-cell	Grid-cell	Grid-cell
Country FE	NO	YES	YES	YES	NO	NO	NO
Quarter FE	NO	YES	YES	YES	NO	NO	NO
Country-Quarter trend	YES	NO	NO	NO	NO	NO	NO
Country-Quarter FE	NO	NO	NO	NO	YES	YES	YES
Grid-cell FE	NO	NO	NO	NO	YES	YES	YES

Clustered standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

Table A8: Alternative standard errors and levels of cell aggregation

VARIABLES	(1) UCDP events hdfe	(2) UCDP events hdfe	(3) UCDP events hdfe	(4) UCDP events hdfe	(5) UCDP events hdfe	(6) UCDP events hdfe
Primary diamond propensity	0.0780**	-0.156*	-0.156	-0.156*	-0.271**	-0.429
* diamond price	(0.0378)	(0.0846)	(0.103)	(0.0837)	(0.121)	(0.340)
Secondary diamond propensity	-0.00264**	0.0118*	0.0118	0.0118**	0.0179***	0.0209
* diamond price	(0.00120)	(0.00608)	(0.00757)	(0.00595)	(0.00680)	(0.0170)
Observations	2,159	448,644	448,644	448,518	101,428	17,765
R-squared	0.519	0.495	0.495	0.000	0.549	0.604
Unit of analysis	Country	Grid-cell	Grid-cell	Grid-cell	Grid-cell	Grid-cell
Country FE	YES	NO	NO	NO	NO	NO
Quarter FE	YES	NO	NO	NO	NO	NO
Country-Quarter FE	NO	YES	YES	YES	YES	YES
Grid-cell FE	NO	YES	YES	YES	YES	YES
Level SE clustering	Country; Quarter	Grid-Cell; Quarter	Country	Spatial HAC	Grid-cell	Grid-cell
Grid-cell size	0.5x0.5 degrees	0.5x0.5 degrees	0.5x0.5 degrees	0.5x0.5 degrees	1x1 degrees	2x2 degrees

* p<0.1 ** p<0.05 *** p<0.01

A final worry may be that results are an artefact of the Modifiable Aerial Unit Problem, a bias that can arise when aggregating point-based data to polygons (Harari and Ferrara 2018). However, results strongly resembling the main results are obtained when using one by one degree grid-cells instead of 0.5 by 0.5 degree grid-cells, indicating that results are not specific to a relatively arbitrary choice of cell size. Using 2 by 2 degree grid-cells does not give statistically significant results. However, given that 2 by 2 degree grid cells represent an area of over two hundred kilometre by two hundred kilometre, and the results in Table 3 of the main text showing that the effect of an increase in the diamond price on violence is highly localized, this may not be surprising.

6.5. **Stationarity of diamond prices and violence**

This section explores the stationarity of the diamond prices and violence, to mitigate concerns that specifications (1) and (2) in the main text are subject to the problem of spurious regression.

A linear time series regression with a dependent and independent variable that are non-stationary – have a unit root – is subject to the problem of spurious regression and produces inconsistent coefficients and invalid t-statistics (Granger and Newbold 1974). Entorf (1997) finds that this problem also applies to panel data when the number of time periods goes to infinity and the number of cross-sectional units is finite (Entorf 1997). This could be cause for concern about the country level regressions, which are based on 52 countries and 42 time periods. The grid-cell level regressions, based on more than 10,000 grid-cells, resemble more a case where the number of cross-sectional units goes to infinity. Philips and Moon (1999) explore several cases of panel regressions with a non-stationary dependent and independent variable, and both the number of time periods and the number of cross-sectional units going to infinity. In all cases considered, linear regression produces consistent coefficient estimates and standard errors (Phillips and Moon 1999)

For the country-level regressions, Table A9 explores the (non-)stationarity of the main variables of interest. It presents results from augmented Dickey-Fuller unit root tests for time series and panel data respectively, including a time trend and (for panel data) subtracting cross-sectional means.

These tests reject the hypothesis that all panels contain a unit root for both interaction terms including the diamond price, suggesting these variables are stationary ($p<0.000$). We cannot reject that the diamond price time series is non-stationary ($p=0.42$). However, all dependent variables capturing conflict (with the exception of violent events according to ACLED – which did not produce statistically significant main results) appear to be stationary in panel data unit root tests ($p<0.0000$). Unit root tests for individual countries reject the null of a unit root at the 5% level or stricter for 34 out of 43 conflict countries when looking at UCDP violent events, 45 out of 49 countries when looking at ACLED fatalities, and 40 out of 43 countries when looking at UCDP fatalities. There is thus no reason to believe that specifications (1) and (2) in the main text include a non-stationary dependent and independent variable, or that they are subject to the spurious regression problem.

Table A9: unit root tests for diamond price time series and country level data

Variable	p-value Augmented Dickey-Fuller test
Time series	
Diamond price	0.4200
Panel data	
Primary diamond propensity * diamond price	0.0000
Secondary diamond propensity * diamond price	0.0000
Violent events ACLED	0.9701
Violent events UCDP	0.0000
Fatalities ACLED	0.0000
Fatalities UCDP	0.0000

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