ON THE ORIGINS OF THE STATE: STATIONARY BANDITS AND TAXATION IN EASTERN CONGO

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Abstract

A positive demand shock for coltan, a mineral whose bulky output cannot be concealed, leads armed actors to create illicit customs and provide protection at coltan mines, where they settle as "stationary bandits." A similar shock for gold, easy to conceal, leads to stationary bandits *in the villages where income from gold is spent*, where they introduce illicit mining visas, taxes, and administrations. Having a stationary bandit from a militia or the Congolese army increases welfare. These findings suggest that armed actors may create "essential functions of a state" to better expropriate, which, depending on their goals, can increase welfare.

1 Introduction

Economists typically presuppose environments where property rights and contracts are enforced by a state. Typically, however, states appeared late through history, and the "essential functions of a state" (Tilly, 1985)—"monopoly of violence," taxation, and protection of the property of those who are taxed—were likely central for modern economic growth (Bates, 2001).[1]

When do the essential functions of a state emerge? Historical research suggests that their origins might be in the activities of armed actors (Tilly, 1985). Indeed, while many armed actors

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[1] Grossman (1994) notes: "Throughout history the responses of human societies to the problems of distributing property and of allocating resources between productive and appropriative activities probably have had greater consequences for welfare than have their responses to the problem of allocating resources among different productive activities taking property as given, which is the problem on which economic analysis traditionally has focused."

typically ended as organized crime, the historical record documents that the most successful were the precursors of today's states (Olson, 1993, Weber, 1946). However, a challenge to examine this question is that *statistics* were first created by states (Scott, 1998). Thus, currently available data would not allow statistical analysis of their origins systematically.[2]

The Democratic Republic of the Congo (DRC) provides a suitable setting to examine the emergence of the essential functions of a state. The central government has lost direct control from vast areas of the east, allowing numerous armed actors and also individuals affiliated to the Congolese army to engage in criminal activities since 1990. They regularly establish illegal monopolies of violence, offer protection, raise illegal taxes, run administrations illegally—thus privately providing "essential functions of a state"—and often enjoy more legitimacy than the central government.[3] Sometimes, they are a de facto government. In this period, large changes in demand for minerals extracted in the east influenced their incentives to invest, or disinvest, in such functions.[4]

As a foundation for this study, I assembled a yearly panel dataset on the behavior of armed actors since 1995 in 650 locations of eastern DRC. Drawing on the theory of optimal taxation, I suggest that, if production can be observed, a higher value of output increases the returns to tax *production*, provide protection, and ultimately to create a monopoly of violence in the location in which output is produced—the essential functions of a state. Instead, if production cannot easily be observed, a higher value of output increases the return to tax people and consumption, and to create an administration to support the collection of such, more sophisticated, tax vector.

To establish a causal relationship, I exploit two demand shocks for minerals extracted in eastern DRC, for which the DRC is a price-taker. At the start of 2000, Sony announced the release of a new video-game console for Christmas, Playstation II, which used coltan as an input, a bulky mineral extracted in eastern DRC whose output is easy to tax. In response, as part of a well-documented speculation move in the industry, demand for coltan by coltan-processing firms

[2]Scholars of the early state argue that the absence of systematic disaggregated data is a major constraint to the development of their field: "Consideration of the political economy of early states is urgent, but one reason it has been neglected is that information on it is so poor" (Southall, 1991). However, many examples of well documented experiences of state formation exist. Mexico's Oaxaca Valley prior to 200 A.D., ancient Titicaca, and Polynesia in the turn of the 19th century are examples of this (Flannery and Marcus, 1996, 2014). Keeley (1996), and Claessen and Skalnik (1978) gather evidence of stateless societies and early states. Flannery and Marcus (1996) argue: "A battle is one of the hardest events to document with archaeological evidence," and "even in regions subdued by force it might require incredible luck to find archaeological evidence for a battle."

[3]The DRC is considered a "failed state" (Fund For Peace, 2013). Raeymaekers (2013) notes: "The expansion of this military-commercial nexus [...] depends on the exploitative tribute armed parties can raise [...] productive enclaves of negotiated peace in a sea of unprotected statelessness."

[4]Nest et al. (2011), Sánchez de la Sierra (2018), Stearns (2011), Verweijen (2013), Stearns and Vogel (2017).

skyrocketed, pushing the daily price from $90 to $590 per kilogram—before it collapsed at the end of the year upon the failure of Playstation II. Then, following the global recession, investors rushed to gold as a safe haven—a mineral whose highly valuable and tiny daily output is impossible to tax, pushing up the price of gold sharply especially after 2006.

The first result is that, in response to an increase in the price of coltan, armed actors create monopolies of violence, i.e. they emerge as "stationary bandits" (Olson, 1993), create illegal customs to tax mining output, and provide protection in the mines where coltan is produced—thus create Tilly (1985)'s "essential functions of a state." This effect, driven by mines near airports where coltan can be shipped exported, is led by non-state armed actors, more prevalent during that shock, often seen as more legitimate than the state. However, in response to the positive demand shock for gold, whose output miners can easily conceal, stationary bandits emerge, not at the mines, but in the villages where miners' families live—the consumption economies (support villages) where they also provide protection and, failing to tax mining output directly, they introduce systems of working permits on mining labor. This effect is driven by privately provided criminal activities of Congolese army individuals, more prevalent during the gold price shock.

The second result is that, when the stationary bandit's mission encompasses the population well-being (popular militia and Congolese army actors), having a stationary bandit benefits household welfare on net. First, the price shocks lead proxies for household welfare (asset ownership, weddings, and migration) to increase significantly *more* in locations that have a stationary bandit, only if they are affiliated to a militia or to the Congolese army. Second, having a stationary bandit from a militia or the Congolese army increases household welfare, but having one from external armed actors does not. To support a causal interpretation, I instrument for the presence of a given stationary bandit using the timing and targeting of a major peace agreement.

The third result is that the gold shock induces stationary bandits to intensify the essential functions they create. In response to a higher gold price, armed actors introduce working permits as well as other more sophisticated taxation systems (poll taxes, taxes for selling in the local food market), in the sense that they are more difficult to collect, and develop a fiscal administration to support their tax collection efforts as well as a judicial administration. Such effect holds even when accounting for changes in the composition of stationary bandits. The coltan price, reversely, leads stationary bandits to dismantle the fiscal and judicial administrations in coltan support villages, an administration "resource curse." This suggests that the opportunity costs of different tax revenue-generating activities govern the allocation of the stationary bandits' limited resources.

The findings of this paper complement scholarship on the origins and trajectories of the essential functions of the state. First, history abounds with examples of armed organizations aiming to govern. The most successful ended up forming states, but many such "states-in-the-making" disappeared (Tilly, 1985). While this process is typically taken as given in economics, other social sciences study it a recurrent process of state formation that is never complete. Second, the contractarian view of state formation, hypothesized in philosophy (Hobbes, 1651, Rousseau, 1762) conceives states as arising from popular will and uses this to explain their positive effect on welfare, while on the other hand, the conflict view, dominant in anthropology and sociology, views states as successful organized crime. The findings of this paper suggest that, when they emerge from popular mobilization, the essential functions of a state can arise from both processes, and they can have a positive effect on the population's welfare . Third, the findings propose an explanation to Tilly (1985)'s "essential functions of the state" at its early stages, as well as their "maturing" (Ardant, 1975), two phases studied in the sociology literature (Claessen and Skalnik, 1978).

The paper also complements the study of civil war in economics, usually constrained by the absence of high quality panel data (Blattman and Miguel, 2010). These data allow me to complement existing explanations of violence. First, Dube and Vargas (2013) and Dal Bó and Dal Bó (2011) suggest that a rise in the price of a capital-intensive commodity increases violence, and explain it as a "rapacity effect," as armed actors fight for the resource. This paper suggests that such an effect may cover subtler changes linked to the ways in which the value is extracted, and which can lead to the emergence of the essential functions of a state—and potentially to their intensification. Second, the dis-aggregated panel data allows me to estimate causal relationships, an approach which, with some exceptions is still rare (Arjona et al., 2015, Dube and Vargas, 2013, Koenig et al., 2017, Maystadt et al., 2014, Nunn and Qian, 2014, Reno, 1999, Weinstein, 2007).

Finally, this paper proposes a new type of "resource curse" (Bannon and Collier, 2003). Two common empirical observations are used in the resource curse literature to suggest that mineral endowments can have a negative effect on the political equilibrium. First, countries that have mineral resources are more prone to conflict. This is often explained as a "rapacity effect," as non-state armed actors have an incentive to seize the state or its property (Bazzi and Blattman, 2014). Second, governments that have access to revenue from resources are less dependent on the population for fiscal revenue, potentially reducing government accountability—the "rentier state."

While the resource curse literature typically takes administration capacity as given, the findings of this paper suggest that administration capacity may itself be endogenous to resource booms. If taxing production is impossible, a resource boom increases the returns to create a fiscal administration to tax income, consumption and wealth. However, if production can be taxed, a resource boom may lead governments to create customs taxation, which require minimal investments, and to reallocate resources away from other sources of revenue generation—thus dismantling their administrative efforts to tax consumption and people. While full-fledged bureaucracies are likely slower to change, this paper suggests that resource shocks can govern the incentives of leaders to create, or instead dismantle, "fiscal capacity" (Besley and Persson, 2009), usually taken as given in this literature—thus temporary resource booms can have long-run effects on tax revenue.

2 Conceptualizing the essential functions of states

2.1 Motivating example

The case of the Nduma Defense of Congo-Renouvelé (NDC-R), formed in 2008, provides a useful example of a group that belongs to the continuum that runs "from bandits and pirates to kings via tax collectors" (Tilly, 1985).[5] The organization, which, in September 2017, was composed of 2,377 combatants and administrators, had the capacity to project violence in a considerable territory. It controlled 108 villages, taxed 38,480 adults, and owned 1,180 spears, 1,198 machetes, 14 guns, 40 grenades, 14 machine guns, 24 RPG, 7 mortars, 2,028 AK47, and 66 satellite phones.

To finance its monopoly of violence, a fiscal agency collects a monthly poll tax in each village the group controls. In order to collect poll taxes, the agency conducts a population census in each village as well as tax audits, and enlists village chiefs, following a system of tax tokens that resembles the Belgian colonial state's fiscal system. The agency is in charege of issuing mining permits and collecting mining output taxes, a weekly agricultural tax in kind (the "ration militaire"), fees on private actors for profiting from public property (the "taxe domaniale"), toll fees on transit, and even a 10% turnover tax on businesses, whose level is set to compete with

[5]Many examples found in my own fieldwork in DRC between 2010 and 2018 show similar patterns. This investigation includes conversations with active officers and combatants of the following armed groups: Nduma Defense of Congo-Sheka, Nduma Defense of Congo-Guido, Mayi-Mayi Padiri, Mayi-Mayi Yakutumba, Mayi-Mayi Kifuafua, Mayi-Mayi Nyakiliba, Raia Mutomboki, Mayi-Mayi Uvira, M23, Mayi-Mayi APCLS, AFDL, as well as their administrative documents. The argument put forward by the paper is not new (Raeymaekers, 2013).

the Congolese state's rate. An intelligence agency monitors the entry of traders in order to tax them as well as enemy activities. The agency is also in charge of administering the profits from the group's "state" monopolies over the sale of beer, liquors, and cigarettes. An administrator, called the "T1," manages the staff of an agency in charge of public finance and human resources.

The group is concerned with order and popular support and, for that purpose, has created a legal system. Sexual offenses, tax evasion, espionage, and theft are penalized. Furthermore, an agency for the relationship with civilians frequently conducts so-called "sensibilisation" campaigns to inform the population about the group's mission (and persuade them to endorse it) as well as to obtain voluntary recruits. The general frequently invokes ancestors of the local ethnic group support the legitimacy of the group's mission. The group also has its own logo and anthem.

In the period of this study, eastern DRC had a significant number of armed actors, from thousands of bandits to hundreds of semi-autonomous battalions of larger organizations which, like the NDC-R, share the problems, and features, of a state-in-the-making—including hundreds of armed actors affiliated to the Congolese army operating criminal protection rackets.[6]

2.2 Origins of the state and the essential functions of a state

Emergence of the essential functions of a state (extensive margin). A dominant view of the state defines it as a "monopoly of violence" (Weber, 1946):[7]

[6]See Raeymaekers (2013), Stearns and Vogel (2017). See also Smith (2015): "In the beginning, there was no government to speak of in the United States of America (USA), but over time the Mai Mai army brought law: 'The more people worked, the stronger the Mai Mai grew. They grew rich from the 50 percent that they earned from the diggers' [...] the United States of America was known as a relatively liberal place with many freedoms and this helped to make it a land of opportunity: 'A person could go from nothing to something, and no one cared who you were or where you were from, what your ethnicity was, so long as you were strong, and could work.' Because so many people wanted to go there, and there was a constant threat to security, when a newcomer visited the USA she had to apply for a visa: 'They gave you an identification card, and the Mai Mai told you, 'Welcome. You are in the USA now, another country. You have left Congo behind.' There were customs officials there, inspecting goods, assessing value, and placing tax." Hoffmann (2015) notes: "Many preferred the justice of the armed groups, which were viewed as more accessible, effective, and cheap." Marchais (2016) writes: "Several auto-defense groups had already emerged as a result of the persistent insecurity but they were loosely organized." On the other side of the continuum, the M23 controlled 5,200 square kilometers, 69,000 civilians and had Ministries of corruption and environment. *New York Times*, Nov 25th 2012. See also: *BBC*, Aug 7th 2012 and *Radio Okapi*, August 7th 2012.

[7]Trotsky (1905) writes: "In any 'normally' functioning state, whatever its form, the monopoly of brute force and repression belongs to the state power. That is its 'inalienable' right, and of this right it takes the most zealous care, ever watchful lest any private body encroach upon its monopoly of violence. In this way the state organization fights for its existence." Tilly (1985): "Back to Machiavelli and Hobbes, nevertheless, political observers have recognized that—whatever else they do—governments organize and, where possible, monopolize violence." Flannery and Marcus (2014): "One of the most dramatic innovations of states is that the central government monopolizes the use of force [...] While individuals in Sumerian society were constrained from violence and revenge, the state had the right to draft soldiers and wage war." See Claessen and Van de Velde (1991). Tilly (1985) writes: "The [...]

"Governments stand out from [racketeers] by their tendency to monopolize the concentrated means of violence. The distinction between legitimate and illegitimate force makes no difference to the fact. If we take legitimacy to depend on conformity to an abstract principle, or on the assent of the governed, these conditions may serve to justify, perhaps even to explain, the tendency to monopolize force." (Tilly, 1985)

Proponents of this view define the essential functions of a state as "eliminating external rivals and oppressing internal opponents," "repressing threats to the property of the governed", and "designing the means to finance these activities" (Tilly, 1985).[8] In the absence of a state, human populations are often governed by traditional chiefs, whose rule is often based on pre-existing religions, social conventions, and reciprocity. Archaeological evidence suggests that the essential functions of the state first emerged when an armed elite, often foreign, aimed to collect taxes, often starting with rudimentary taxes on observable output. So-called early states were recorded as early as 3,000 years BCE.[9] A dominant explanation of their emergence is that the value of the output that can be taxed, and the ease with which it can be taxed, are important determinants in the elite decisions to develop such functions (Ardant, 1975, Carneiro, 1970, Earle, 1997). Because of their extractive motive, even if many early states attempted to create ideological and religious justifications for their rule, they often failed. A large number did not have legitimacy—so-called

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argument stresses the interdependence of war making and state making and the analogy between both of those processes and what, when less successful and smaller in scale, we call organized crime. War makes states."

[8]While Tilly (1985, 1990) describes the creation of modern European states, his theoretical work permeates periods: "The argument grows from historical work on the formation of national states in western Europe [...] But it takes several deliberate steps away [...], wheels, and stares hard at it from theoretical ground" (Tilly, 1985). Baumol (1995) writes: "[...] the economics of crime promises to offer profound insights into the origins and workings of governments, not as most of us know them, but like those that have ruled the bulk of humanity in the past, and continue their sway in many countries today," Hirschfeld (2015): "[D]emocratic governments that regulate markets and protect individual rights are recent innovations that are still not the norm." See Carneiro (1970), Claessen and Skalnik (1978), Claessen and Van de Velde (1991), Cohen and Service (1978), Flannery and Marcus (1996), Hirschfeld (2015), Service (1975), Skaperdas and Syropoulos (1996), and also the evolution of states into modern states (Ardant, 1971, Scott, 1998, Tilly, 1985, 1990, Tilly and Ardant, 1975). Such state functions have been documented in the Italian Camorra and the Sicilian mafia (Gambetta, 1996); gambling rackets; organized crime in America, such as the violent organizations that emerged from product prohibitions or well-studied highway gangsters in the United States of America, which established stems of tolls and protection rather than arbitrary predation (Hirschfeld, 2015). Popular views tend to abstract from the underlying social process prior to their recognition as a state in the international state system.

[9]See Thornton (1983). Flannery and Marcus (2014) document the three main sources of chiefly power: the *mana* (supernatural energy), the *tohuga* (skill/expertise), and the *toa* (toughness). While the rule of chiefs usually relies on supernatural powers (mana) and skill (tohuga), governing populations outside the immediate clan requires the use of toughness, or force (toa). States thus form when the basis of governance shifts to force, for instance when populations are ruled by chiefs who expand their rule outside the immediate clan: "When [...] the expanded territory grows beyond the limits that a chief can administer through the *usual* methods, he is compelled to make changes in administration and political ideology, and a state begins to form" (Flannery and Marcus, 2014).

"inchoate" early states (Claessen and Skalnik, 1978).[10]

Extensive margin and population welfare. If state functions are used for the interest of the population—as in the case of popular militia or "inclusive" political institutions—they may enable growth through the protection of property rights they provide. However, state functions can be used to the detriment of the population welfare (Acemoglu and Robinson, 2012, Heldring, 2018), as evidenced by the fact that many states arise as protection rackets.[11]

Intensification of the essential functions of the state (intensive margin). In some cases, moving beyond the collection of simple taxes on observable output, states "matured" along a continuum (Claessen and Skalnik, 1978)—indicating state formation on the intensive margin. The trajectory of European modern states suggests that armed actors' efforts to seek tax revenue can account for changes along such intensive margin (Ardant, 1975). High value international trade in England, which could be taxed with easy-to-administer customs, increased the focus on customs as a source of tax revenue. The French government revenues, in contrast, hinged on taxing transactions in the interior. This led the government to introduce poll and consumption taxes, tolls, rural fairs, city walls, and to create the organizational capacity to support the collection of such taxes.[12]

[10] "Frank recognition of force's central place in governmental activity does not require us to believe that governmental authority rests 'only' or 'ultimately' on the threat of violence. Nor does it entail the assumption that a government's only service is protection" (Tilly, 1985). Legitimacy is also implied: "Legitimacy is the probability that other authorities will act to confirm the decisions of a given authority. Other authorities [...] are much more likely to confirm the decisions of a challenged authority that controls substantial force" (Tilly, 1985). Contractarian narratives of state formation can be seen as the product of successful legitimation. Claessen and Skalnik (1978) documents the effort of Carolingians to provide ideological foundations to their rule. Olson (1993) makes a similar point: "Since history is written by the winners, the origins of ruling dynasties are, of course, conventionally explained in terms of lofty motives rather than by self-interest."

[11] See Bates (2001), Grossman (2002), Hirshleifer (1995). Hobbes (1651) writes: "In such condition there is no place for industry, because the fruit thereof is uncertain, and consequently [...] no account of time, no arts, no letters, no society, and which is worst of all, continual fear and danger of violent death, and the life of man, solitary, poor, nasty, brutish, and short." See Keeley (1996), Tilly (1985). Examples of inequality in favor of an elite class that controlled the "guns," and slavery, abound the Early state record (Cohen and Service, 1978)."[S]tate formation involved thousands of deaths, and thousands [...] were converted into slaves" (Flannery and Marcus, 2014).

[12] See Ardant (1966). Ardant (1971) describes the force behind the English state development: "This facility in collecting taxes was linked [...] to the decidedly important increase of trade". Johnson and Koyama (2014) note: "The different geography of the two countries also explains why internal trade barriers and tolls provided an important source of revenue for local rulers in France; in England, sea transport was always more important than inland transport and this reduced the value of local trade barriers and made it more straightforward for the monarchy to take control of local customs taxes." See Ardant (1975): "Taxes against various kinds of rents are also simple to carry out. Production is sufficiently concentrated so that taxes can be levied at that stage which will eventually be passed on to the consumer." and "Great Britain's economic structure provided the foundation for her fiscal capacity by allowing her to give the most important role to the taxation of commercial activities [...] Customs, Excise, Stamp [...] Several factors made it inevitable that England have trade, the channels of which were rather easy to keep an eye on, in spite of smuggling: England was an island, her climate practically precluded the production of wine." "The financial administration understood, in advance the problems of a turnover tax applied to small business [...] It would seem better to tax the consumption of storekeepers, small businessmen, artisans, their workers [...] City life assumed the circulation of foodstuffs and manufactured objects [...] Products could be

2.3 Organizing question

Extensive margin of the essential functions of the state. Today's stationary bandits provide a useful starting point to study the emergence of essential functions of states (Olson, 1993).[13] First, stationary bandits hold a monopoly of violence in a territory often by eliminating their rivals—*war making* and *state making*. Second, because they hold a stable monopoly of violence, stationary bandits can sustain credible commitments of tax output to finance their operations—*extraction*. Finally, through their taxes, stationary bandits are a (partial) residual claimant of economic activity in their territory. Thus, it is in their interest to protect property of those who produce—*protection*. Taxation of production, stationary bandits, and protection are thus closely related.

Extensive margin and population welfare. A stationary bandit may increase GDP if they create more value added through the effect of their protection on investment than they destroy through the disincentives induced by their taxes. Their effect on GDP thus depends on the counter factual insecurity of property rights, and the distortions their tax rate generates. Yet, even if a stationary bandit may increase GDP, they may expropriate the surplus away.

Intensive margin. If taxing output is difficult, a stationary bandit can develop systems of direct taxation and taxes on consumption to capture the economic surplus in circulation. To support the collection of those taxes, they can create a fiscal administration, and to promote economic exchange (and thus tax revenue), they can hold a judicial administration.

Organizing question: When do stationary bandits emerge? Does the population benefit on

taxed in transit, preferably at the point through which they had to pass to enter the cities, especially when cities were still surrounded by walls [...] One can understand the preference of finance ministers for indirect taxes, but even these taxes faced the same obstacle. When the manufacture of a whole series of products is concentrated in one setting, as it is today, it is possible to arrange verification of production [...] When there are small scattered enterprises, this solution is impossible [...] All that remained was to control circulation [...] However, despite all the advantages that the ruling classes could find in this kind of tax system, it was not sufficient [...] States could not bypass direct taxation of the largest part of the taxable population[...] In the seventeenth century the need to find a satisfactory fiscal system was so strong that various European countries resorted to another tax which had nothing to do with the ability to pay — the poll tax. Gone were the delicate problems of evaluating wealth, one merely had to count the human beings in a nation and place the same tax on each head" (Ardant, 1975).

[13] Historical documentation contains rich evidence that currently recognized states are self-selected organizations that competed for extraction (Tilly, 1985): "Power holders did not undertake those three momentous activities with the intention of creating national states. Nor did they ordinarily foresee that national states would emerge from war making, extraction, and capital accumulation." Tilly (1985) illustrates this process: "Most of the European efforts to build states failed. The enormous majority of the political units which were around to bid for autonomy and strength in 1500 disappeared in the next few centuries, smashed or absorbed by other states-in-the-making. The substantial majority of the units which got so far as to acquire a recognizable existence as states during those centuries still disappeared. And of the handful which survived or merged into the nineteenth century as autonomous states, only a few operated effectively [...] Only the positive cases are well-documented." Flannery and Marcus (2014) write: "[Competition between states] produces winners and losers. We flock to the winners like paparazzi, forgetting that the competition itself was the real engine of change."

net? And, when do they create fiscal and legal "capacity"? I next present a simple model.

2.4 Simple model

A simple model is derived in Section A. This section presents the model and its implications in words. In a production economy, workers produce output. In a consumption economy, households use labor income from production to invest and to consume. Roving bandits regularly expropriate output or wealth. An armed actor can use brute force to form a monopoly of brute force in either economy. In that case, he can design a credible taxation plan. In a production economy, he can tax output and labor (working permits). In a consumption economy, he can tax returns on investments. Households can evade taxes at some cost, but armed actor can create an administration to increase such cost, as in Besley and Persson (2009). The armed actor maximizes a weighted average of his own revenues from expropriation and the population welfare. In general, this produces the following testable implications. First, monopolies of brute force are more likely to form in a production economy when the output price is high. This effect is *stronger* if output cannot be concealed, and in locations where it can be shipped. Second, monopolies of brute force are more likely to form in consumption economies when valuable wealth is in circulation, especially if output in the production economy can be concealed. Third, the more the armed actor controlling the monopoly of brute force values the welfare of his population, the more the monopoly of brute force benefits the population. Fourth, in a consumption economy, a fiscal administration that curbs tax evasion can increase revenues from expropriation, especially when wealth in circulation is high.

3 Empirical strategy

3.1 Empirical setting

In 1998, following an attempted coup by the Rassemblement Congolais pour la Democratie (RCD), RCD divisions, multiple regional militia known as the Mayi-Mayi, and the Forces De Libération du Rwanda (FDLR) gained control over the eastern half of the country.[14] Although their interests were originally political, economic incentives quickly became central in the Second Congo War.

[14]The First Congo War lasted from 1996 to 1997. The Second Congo War, referred to as "The Great African War," involved nine foreign armies, and thirty local militia (Nzongola-Ntalaja (2002) and Stearns (2011)).

Ensuing a peace agreement signed in Sun-City (South Africa) in 2003, the RCD and major self-defense groups agreed to vacate eastern DRC and integrated the newly formed national army (FARDC). While some refused to join, individuals originating from these groups who integrated the FARDC maintained their command networks. This merger further undermined the distinction between armed groups and the state. In 2017, 132 armed groups were active (Stearns and Vogel, 2017), controlling up to 95% of the territory in some districts (Radiookapi, 2013). The FARDC controlled valuable areas of gold, timber, cacao, coffee, and systematically operated protection rackets and raised illicit taxes (Verweijen, 2013).[15]

Mineral extraction in eastern DRC, done by "artisanal miners," is labor-intensive. Millions of artisanal miners exploit the minerals today with minimal infrastructure (World Bank, 2008). The two dominant minerals are coltan and gold. Gold has higher value-to-weight and daily production is small and uncertain. Owing to the poor road infrastructure, coltan output is shipped by plane until it reaches global markets. Artisanal miners are partial residual claimants. Local militia, foreign armed actors, and criminal units in the FARDC regularly provide security and tax.

At the start of 2000, Sony announced the release of a new video-game console, Playstation II, for Christmas, which used columbite-tantalite as a key input (called coltan in the DRC). Columbite-tantalite processing firms rushed for coltan in DRC, pushing the daily price from $90 to $590 per kilogram, before it collapsed during the Christmas season upon the failure of the Playstation II. Then, following the global recession, investors begun a rush to gold as a safe haven. The price of gold rose sharply especially after 2006, reaching levels in 2012 of up to 6 times higher than the pre-shock levels. Figure 1 shows the prices of gold and coltan through these shocks.[16]

Rural Eastern DRC is partitioned into municipalities. Each municipality has exactly one village, in which households are located—henceforth referred to as the "support village." Mineral deposits, each located in one municipality, were discovered in the 20th century, prior to the study period.[17] Mineral deposits are often far from their support village. The average distance of a mining site to its support village in this paper's sample is 10 hours of walk (the maximum is 180).

[15]See Marchais (2016). Stearns et al. (2013) note: "Patronage networks in the FARDC reinforce the orientation of the army towards revenue-generation rather than defence [...] Illegal taxation also occurs at roadblocks along main transport routes, and at markets, border posts, harbours, and airports." Among armed groups, the Raia-Mutombokis controlled 95% of the Shabunda territory in 2013, and a total of 30,000 squared kilometers. See Stearns and Vogel (2017), Nest (2011), Nest et al. (2011), Nzongola-Ntalaja (2002), Stearns (2011), Verweijen (2013).

[16]See Nest (2011), Stearns (2011), and United Nations Security Council (2001). The DRC's global gold output share is .08%. For coltan, it went up from 0% in 1997 to 12% in 2000, and 20% in 2010. A second price shock to the price of coltan hit in 2011 (source: United States Geological Survey (2016)).

[17]Figure F.1 in the online appendix represents the typical municipality graphically.

Minerals extracted at the mine often circulate through the support village. For low value-to-weight minerals (coltan), transporters carry bags of up to 75 kilograms by foot from the mine to the support every day. For gold, the supply chain is more difficult to track because miners and carriers systematically conceal gold output. Reflecting this pattern, gold is known as the "immaterial mineral." World Bank (2008) suggests $125 million are exported yearly.[18]

3.2 Data collection strategy and data

A team of ten surveyors reconstructed a yearly historical dataset on 239 support villages and their corresponding 411 mining sites in Sud Kivu and Nord Kivu, based on recall.[19] Reconstructing a municipality's history based on recall is subject to three challenges: first, classic measurement error due to imperfect recall of the magnitudes of events; second, classic measurement error due to imperfect recall of the dates at which events took place; third, reporting bias for sensitive information. To address these challenges, I used established methods in recall studies from eyewitnesses and, based on three months of piloting, tailor them to the cultural context.

In each support village, where municipality experts live, the surveyors trained "history specialists" to consolidate, during one week, a municipality history dataset. Each day, the surveyors monitored the specialists' work and re-trained them to improve accuracy in the data. In the course of the week in each support village, the surveyors administered private interviews in six (Sud Kivu villages) to eight (Nord Kivu villages) randomly selected households. In each household, they discussed the municipality's and household's history with all available household members and, after randomly selecting a respondent, they discussed the respondents' individual history in private. During the week, they also prepared an in-depth qualitative report about the municipality's

[18] While a coltan miner might produce up to fifty kilograms of coltan per day, a typical day of work mining gold yields between a tenth and ten grams of gold output. In the absence of prohibitively costly X-ray equipment, regularly used in other countries, the miners conceal gold output (Geenen, 2013). Miners often digest the output in order to sell it in a major urban center. The average world price per kilogram of gold in the period was $17,404, compared to $136 for coltan. Daily production per worker is approximately 20 kg for coltan, and between 1 and 10 grams for gold. See De Failly (2001), Nest (2011), Geenen (2013), and World Bank (2008).

[19] In Sud Kivu, I sampled all coltan municipalities. Since gold municipalities are more numerous, I selected a random sample of gold municipalities within each administrative division (Territoire). I also sampled 20 pure agricultural municipalities, matching on all geographic characteristics known ex-ante within administrative division—I minimized the Mahalanobis metric between mining and agricultural municipalities. I identified municipalities endowed with minerals in existing datasets (International Peace Information Service, 2009, Référentiel Géographique Commun, 2010), and completed them by conducting prospections in each Territoire prior to sampling. In Nord Kivu, because of the importance of other economic activities unlike in Sud Kivu, I sampled all municipalities with mining activity or any other meaningful economic activity (banana, coffee, cacao, beans).

history based on conversations with selected individuals. Finally, in each support village, the surveyors held a day-long meeting with the history specialists and contrasted their own data to the data gathered by the history specialists during the week. By the time this meeting was held, the surveyors were able to detect and correct reporting biases among the history specialists. The data from this meeting is the main source of data for this paper.[20] Figure 2 presents the sample.

3.3 Econometric strategy

With the retrospective local output price data at hand, I could use all years for which I have the full sample (1995-2013), include municipalities that have coltan, gold, or other profitable endowments (cassiterite, tungsten, coffee, beans, cacao, as well as the matched sample of agriculture municipalities) in the following linear probability model, estimated through ordinary least squares:

$$Y_{jt} = \beta_t + \alpha_j + \gamma_c\, C_j \;\; p_{c,t} + \gamma_g\, G_j \;\; p_{g,t} + \varepsilon_{jt}$$

where $Y_{jt} \in \{0, 1\}$ is a dummy corresponding output taxation, stationary bandit, and security services (extensive margin) or more sophisticated taxes and creation of a fiscal and judicial administrations (intensive margin) in municipality j in year t. The terms α_j and β_t are municipality j and year t fixed effects, $C_j \in \{0, 1\}$ (G_j) indicates whether municipality j is endowed with coltan (gold), $p_{c,t}$ ($p_{g,t}$) is the logarithm of the local price of coltan (gold) at year t.[21]

However, the local price of mineral output is (quite plausibly) endogenous to the behavior of armed actors, and thus the exogeneity assumption $E[\varepsilon_{jt}|G_j p_{g,t}, C_j p_{c,t}] = 0$ is almost surely violated. I can, however, use the price of minerals in the United States (US), as long as they are unaffected by the behavior of armed actors in the corresponding DRC locations. First, the DRC share of gold supply is insignificant and thus its effect on the world price is negligible (United States Geological Survey, 2016). Thus the exogeneity assumption can hold reasonably if, instead

[20] The specialists were involved in the mining sector and the village elders, easy to identify due to the tradition of oral history. Data collection activities took place from July 2012 through June 2013 in Sud Kivu, and from February through October 2015 in Nord Kivu. Section B in the online appendix describes each variable in detail. Section C describes this methodology, the contextual factors that reduced recall error, and further design improvements to reduce the likelihood of such errors, and replicate and discuss the results with alternative data sources. Finally, Figures F.2 and F.3 provide a validation test for the demand shocks. Figure F.2 shows nighttime lights. Zonal statistics show that in the year 2000, the provincial capital of North Kivu (and Rwanda) lightens, reflecting the increase in economic activity in the coltan region. Figure F.3 shows the average occupational choice.

[21] Source: United States Geological Survey (2016) Table F.1 provides descriptive statistics.

of local gold prices, I use US prices. Furthermore, the price of gold rises sharply after 2006 as a result of speculation in financial markets. Second, the exact share Congolese coltan in world supply is unknown (Nest, 2011), although it hardly surpasses 20%. More importantly, the price fluctuation in the year 2000 arises from very well-documented speculation in the industry (Stearns, 2011, United Nations Security Council, 2001). Failing to be met by industrial supply from the major supplier in Australia, demand rushed to the spot market for coltan upon the announcement of Playstation II.[22] I thus run the following reduced-form specification:

$$Y_{jt} = \beta_t + \alpha_j + \gamma_c \, C_j \;\; p^{US}_{c,t} + \gamma_g \, G_j \;\; p^{US}_{g,t} + \varepsilon_{jt} \qquad (1)$$

where $p^{US}_{c,t}$ ($p^{US}_{g,t}$) is the logarithm of the local price of coltan (gold) at year t. The main results of the paper are based on this reduced form specification for two reasons. First, local estimates of output prices, constructed through recall, are extremely unreliable. Figure 1 presents the survey estimates of the local price data and Section E presents a 2SLS estimation of the effect of local price on armed actor behavior, alongside 12 other robustness checks. The coefficient magnitudes are significantly larger (and significant) in the 2SLS. Second, the coltan results are unchanged when I restrict the analysis to [1999, 2001], the only interval in which the US coltan price is credibly exogenous (shown in the replication file). As a result, the coefficients in the main specification indicate the effect of a percentage increase in the US price on the probability that Y_{jt} occurs.

In all core analysis, I tackle two concerns about standard error estimation in panel data. First, the mines connected to the same support village could have correlated shocks. Thus, for the analysis of mines, I average the mining site*year observations at the municipality*year level, and remove redundant observations (unweighted collapse), and for the analysis of support villages, I use the support village*year observations, but collapse the mining treatment variables at the level of the municipality*year. Second, the error term and the price might be autocorrelated. Thus, I cluster the standard errors at the level of the municipality. Furthermore, to shield against multiple comparison problems, I also report the results using mean indices, the mean of the corresponding outcomes normalized to mean zero and standard deviation of one.

[22]See (Nest, 2011): "Ordinary Congolese [did not] know that what was [ostensibly] tin mining also produced significant quantities of an obscure mineral."

4 Emergence of the essential functions of a state

4.1 Conflict: violent attacks

Figure 3 shows the proportion of municipalities attacked through the years. The share of coltan municipalities that are attacked rises in 65 percentage poings in the year 2000, against 25% for gold municipalities. Table 1, column (1), supports the results econometrically.[23] This result is consistent with a "rapacity effect" (Dube and Vargas, 2013), indicating that armed actors fight for the control over valuable resources. This might lead one to conjecture that stealing gold is hard and thus revenue from mining gold deters participation into violent appropriation activities.

However, the behavior of armed actors is often more complex than outright theft. As described in the next section, the shock leads to the emergence of taxation on mining production, protection of mining workers and their families, and ultimately to "stationary bandits," often a profitable strategy to extract revenue that embodies the essential functions of a state.

4.2 Explaining output taxation, stationary bandits, and protection

There are two major types of taxation related to mineral extraction. The first is taxes on output, typically through customs: stationary bandits block the road through which output is transported, inspect the output on transporters, and charge a tax proportional to the output. Customs taxation is inherent to taxation of voluminous minerals. In gold mining sites a customs tax would face systematic tax evasion and is thus is rarely observed. The second is entry fees (also called working permits or visas). They are more prevalent in gold sites, where customs taxation is impossible.[24]

Extensive margin. Table 1 shows the results from specification 1. Column (2) uses a dummy indicating whether an armed actor imposed customs taxation on mining output at the exit of the mine. Column (3) uses a dummy indicating whether an armed actor imposed an entry fee to work at the mine. Column (4) uses a dummy indicating whether an armed actor had established a monopoly of violence at the mine. Column (5) uses a dummy indicating whether an armed

[23] Table F.2 in the online appendix shows additional robustness for the analysis of attacks at the municipality.

[24] A Wilcoxon-Mann-Whitney test shows stationary bandits set up customs taxes in coltan mining sites more frequently than in gold sites, and labor fees less frequently. Table F.1 presents the descriptive statistics for mining sites which have coltan (but not gold) and mining sites which have gold (but not coltan). Armed actors also may request output quotas in kind, although these are less regularly enforced and more difficult to measure. The survey in most areas excluded other forms of output taxation.

actor provided a security service at the mine. Column (6) uses the normalized mean index at the mine.[25] Columns (7)-(9) show stationary bandit activity at the corresponding support village. Column (7) shows whether a stationary bandit was installed and Column (8) whether an armed actor provided a security. Column (9) uses the normalized mean index at the support village.[26]

While the coltan price is associated with the emergence of the essential functions of a state based on customs taxation, stationary bandits, and protection at production sites, the gold price leads armed actors to capture benefits through other means. The gold price leads to the emergence of daily mining working visas, and stationary bandits and protection emerge instead in the support villages. Doubling the US coltan price (local coltan price) increases the mine-level extensive margin index by .16 (.17) standard deviations, doubling the US gold price (local gold price) increases it by .33 (.61) standard deviations at the village (the effect of the local price is estimated in a 2SLS).[27]

Figure 4, Panel A, shows that, prior to the shock, coltan ares and the rest are on parallel upward trends, reflecting well-known timing of the First and Second Congo wars. The coltan shock leads the extensive margin outcomes at coltan mines to diverge from the rest, and it takes them three to six years to recover the level of the other areas.[28]

These results reflect a consistent underlying tendency in the data. Figures F.4 and F.5 in the online appendix repeat the estimation procedure for each of all 116 possible year intervals for the extensive margin index. The results replicate in the large majority of year intervals.[29]

[25] The extensive margin index at the mine is constructed as the mean of customs taxation, entry fees, stationary bandit, and security service, normalized to mean zero and standard deviation of one. Removing entry fees from the index, not based on output, significantly increases the coefficient estimate.

[26] Constructed as the mean of village stationary bandit and security, de-meaned, in units of standard deviation.

[27] Section E in the online appendix describes 13 robustness checks, including the 2SLS estimation for the effect of the local price. The results, presented in Tables F.5, F.6 and Figures F.4, F.5, F.6, F.7, F.8, are robust to the large majority of these checks.

[28] A note on parallel trends: a formal test determined that the assumption of parallel trends can be retained. To do this, I constructed a dummy indicating post 1999, and a dummy indicating whether the municipality has coltan. I then ran the following specification: $Y_{jt} = \alpha + \beta_1 POST_t + \beta_2 TREAT_i + \beta_3 POST_t * TREAT_i + \beta_4 POST_t * TREAT_i * t$. The coefficient on β_3 is unaffected by the inclusion of $POST_t * TREAT_i * t$ and the coefficient on β_4 is negative and its magnitude is 2000 times smaller than β_3. Similarly, Column (4) of Tables F.5, F.6 shows that no anticipatory effects, a necessary condition for the parallel trends assumption, holds: the leads have no positive effect and leave the contemporaneous coefficient unaffected. A note on persistence: Existing descriptions of the sector (United Nations Security Council, 2001) and data on local traders' retrospective expectations of price levels, which were collected in this study, suggest local traders expected the coltan price shock to be permanent and its fall to be temporary. Thus, they stockpiled coltan years after the global price shock. This accounts for the sustained price. Additional analysis suggests that the persistence of the local price cannot explain why such functions persist. See United Nations Security Council (2001) and Table F.3 in Section D.

[29] The figures show that $\hat{\gamma_C}$ ($\hat{\gamma_G}$), the estimated coefficient on $C_j p^{US}_{c,t}$ ($G_j p^{US}_{g,t}$) in regression of mine-level data collapsed at the municipality/year level (support village/year level regressions), is positive in 70% (70%) of the year intervals. Both are strengthened when I include the interaction with distance to airports, indicating that the effect is strong for mines and support villages close to airstrips, and easier to detect at the mines. In contrast, $\hat{\gamma_G}$,

Heterogeneous effects by trade infrastructure. The extensive margin effect for coltan, but not for gold, is concentrated in mines (and support villages) that are near an airstrip—through which coltan is usually exported (due to the poor road infrastructure and the low value to weight ratio).[30]

4.3 Who are the stationary bandits?

Even as the boundaries between them are porous, four types of armed actors populate the sample. First, there are village self-defense militia. These are formed by villagers themselves to protect the population or obtain revenge. Second, there are regional militia, whose origins as village militia are trumped by their larger scale. They often extend control to other locations, where they often have weak ties to the population. Third, other armed actors represent the interests of foreign ethnic groups, often semi-autonomous units of large organizations (henceforth, external actors).[31]

Finally, there is the FARDC. The FARDC, was "created in 2003 by a merger of the belligerents of the Second Congo War" (Baaz and Verweijen, 2013), is infiltrated by organized crime networks who generate illicit revenue systematically. Despite its mandate to protect the population, the FARDC actors operate mafia-style protection rackets comparable to other armed actors, extort, sell protection, raise illegal taxes, and its members establish themselves privately as stationary bandits (Verweijen, 2013). Members of the army, so-calld "soldiers without an army"(Verweijen, 2018) are former armed groups' members who kept their structures of command but "upgraded" to the FARDC to improve their control over illegal trade, as it offered an umbrella for organized crime (Verweijen, 2015). Individual armed actors of the FARDC took control of the illicit taxing in gold areas, as well as the illicit trade of timber and coffee (Stearns, 2011, Verweijen, 2013). Even as the FARDC also performs some other functions of the Congolese state (territorial integrity), it can be understood as permeated by organized crime with weak central command. The taxes

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the estimated coefficient on $G_j p_{c,t}^{US}$ in the regression of mine-level data collapsed at the municipality/year level, is zero or negative in 69% of the year intervals, and no positive coefficient is distinguishable from zero.

[30]Let $D_j^a \in \{0,1\}$ indicate whether the distance of municipality j to the closest airport is below the median. When I include $C_j p_{c,t}^{US} D_j^a$ and $p_{c,t}^{US} D_j^a$ the coefficient on $C_j p_{c,t}^{US}$ captures the marginal effect of the coltan price on municipalities that are close to an airport. Table F.4 presents the results using a dummy for whether distance to the closest airport is above the median. The effect of the coltan price shock is concentrated near airports. In contrast, the effect of the gold price shock at the support villages is equally strong close and far from airports. Results using continuous distance to airports are identical.

[31]See Marchais (2016): "The particularity of [Mayi-Mayi and Raia Mutomboki] was the fact that—at least in their initial stages, they were supported and mediated by local structures of authority and social organization and enjoyed popular support, in sharp contrast to more "top down" insurgencies such as the CNDP and M23." External actors include the Tutsi-led RCD, CNDP, AFDL, M23, PARECO, and the Hutu-led FDLR/Interahamwe.

collected by FARDC, illegal, are requested by individuals privately acting as stationary bandits.

Table 2 provides support for this classification. Of 615 stationary bandit episodes at the support village, 19% are regional militia, 18% are village militia, 37% are external armed actors, and 26% are FARDC. The stationary bandits differ in their composition and acceptance (Panel A). First, militia have closer ties with the population. On average, 93% of village militia members are co-ethnic with the village chief, against 29% for regional militia and 18-19% for external groups and FARDC. Second, village militia and the FARDC are seen as more legitimate. Referring to each stationary bandit that controlled their village, households reported in the household survey that the stationary bandit was seen as legitimate in their view in 75% of episodes when the stationary bandit was a village militia, against 69% for the FARDC, and 20% and 17% for regional militia and external armed actors. Third, external armed actors account for a larger share of violence against the population, and of a more violent nature (Panel B). Indeed, 60% of the 931 support village attacks recorded in the survey are perpetrated by external armed actors, 72% of their attacks include pillages, 58% sexual violence, 56% kidnapping, and 61% death. In contrast, militia and the FARDC account for 33% and 6% of attacks, which are significantly less gruesome.

The stationary bandits also differ in the essential functions that they develop (Panel C). First, all stationary bandits, irrespective of their motives, engage in illicit taxation of production. Regional militia and external groups use customs taxes more frequently than entry fees (respectively 66% vs 55% and 46% vs 33%), the FARDC and village militia do the reverse (respectively 33% vs 38% and 22% vs 47%). Second, the FARDC provides security at the mines 69% of years; regional and village militia, created for protection, 62 and 67%; while external armed actors, 62%.

Militia and external groups respond to the coltan price. Armed actors affiliated to the FARDC, absent during the coltan shock and more numerous during the gold shock, respond to the gold price. Indeed, excluding the FARDC strengthens the effect of the coltan price and weakens the effect of the gold price.[32] The armed actors known to be the strongest (regional militia, external Tutsi, and FARDC) sort into the most profitable village/mine, evidence that contestation governs the allocation of stationary bandits to places. Section A provides a formal derivation.

[32]Table F.7 and Figure F.9 show composition. Tables F.8 and F.9 exclude FARDC and the rest. The RCD (external) created their own village militia. This fully accounts for the effect of the coltan price on village militia.

5 Essential functions of a state and household welfare

5.1 Measuring the value of living in a location for households

I use the data from the random sample of households interviewed at each support village to measure household welfare. First, I construct a savings index applying principal component analysis for categorical data to the household's yearly cattle acquisitions. Second, I use the log (plus one) of yearly weddings celebrated in the village—a costly and prestigious investment in a bride-price society that contains implausible outliers. Third, similarly, I use the the log (plus one) of the number of migrants into the village to elicit changes in the relative desirability of living in a village. Cattle, weddings, and immigrants, rare events, are easy to recall using the time cues. Fourth, I combine them into a welfare index using principal component analysis, also normalized.

I address three issues specific to household panel data. First, changes in mineral prices may lead households to migrate. Thus, to isolate changes in household welfare from changes in the (potentially endogenous) composition of households, I only include households who had settled in the support village prior to 2000. I use changes in the welfare of these households over time.[33] Second, households in a support village may have common year shocks. I thus aggregate the resulting sample of households into support village*year means. Third, household outcomes are likely autocorrelated. I thus cluster standard errors at the level of the support village.

The analysis examines the effect on welfare of having a stationary bandit of a particular type. I pool regional and village militia into militia because village militia are a small sample (112 events). The effects for militia shown in the next section are driven by regional militia, and the coefficients for village militia are insignificant, reflecting they are weaker to provide protection and that some local militia (called "Local Defense") were satellite groups created by external organizations.

5.2 Heterogeneous effects of the mineral price shocks

Let SB_{jt} indicate whether a stationary bandit is present in support village j at year t. Let $External_{jt}$, $Militia_{jt}$ and $Army_{jt}$ respectively indicate whether a stationary bandit affiliated to an external organization, to a (village or regional) militia, or to the FARDC, is present in the village—if $SB_{jt} = 1$ then $External_{jt} + Militia_{jt} + Army_{jt} = 1$. I include the terms $C_j * p^{US}_{c,t} * SB_{jt}$,

[33] Results are unchanged including only respondents who were born in the support village, or including only the years in which the respondent lived in the support village.

$C_j * p^{US}_{c,t} * SB_{jt} * Militia_{jt}$, and $C_j * p^{US}_{c,t} * SB_{jt} * Army_{jt}$ in specification 1, using the welfare outcomes as dependent variables. The coefficient on $C_j * p^{US}_{c,t}$ estimates the effect of the coltan price in support villages without a stationary bandit. The coefficient on $C_j * p^{US}_{c,t} * SB_{jt}$ estimates its additional effect in support villages that have a stationary bandit affiliated to an external organization. The coefficients $C_j * p^{US}_{c,t} * SB_{jt} * Militia_{jt}$ and $C_j * p^{US}_{c,t} * SB_{jt} * Army_{jt}$ respectively estimate the additional effect of the price due to having a stationary bandit affiliated to a militia, or to the FARDC, compared to its effect when the stationary bandit is from an external organization.[34]

Table 3 presents the results. Columns (1) through (4) respectively use the savings index, weddings, immigrants and the welfare index as dependent variables. Panels A and B respectively present the results for the coltan and gold price. The coltan price increases household welfare in locations where there is no stationary bandit (row 1), but its effect is identical in locations that have an external stationary bandit (row 2). However, its effect is respectively 11% (p-value=0) if the stationary bandit is instead affiliated to a militia (column 4)—the FARDC is absent during the coltan shock. Similarly, both militia and the FARDC are associated with a significant effect of the gold price on household welfare (Panel B). One may worry for obvious reasons that stationary bandits locate in support villages with better price response potential. Controlling for time-varying effects of constant village characteristics that predict their suitability for stationary bandits, however, leaves the results unchanged.[35] I next describe a strategy to identify a different estimand: the effect of different stationary bandits on household welfare.

5.3 Effect of stationary bandits on household welfare: OLS and IV

OLS: I first implement the following specification:

$$W_{jt} = \beta_t + \alpha_j + \gamma_w \, SB_{jt} + \varepsilon_{jt} \tag{2}$$

[34]Section 2.4 predicts that militia and FARDC should have a more positive (less negative) effect on welfare than stationary bandits affiliated to an external organization. I thus estimate the marginal effect on welfare of a militia stationary bandit, using as baseline the effect of an external stationary bandit. It does not predict that militia have a positive effect on welfare. To estimate that, one would include in the specification the terms $C_j * p^{US}_{c,t}$, $C_j * p^{US}_{c,t} * External_{jt}$, $C_j * p^{US}_{c,t} * Militia_{jt}$, $C_j * p^{US}_{c,t} * Army_{jt}$. The coefficient on the latter three terms estimate respectively the marginal effect of having an stationary bandit affiliated with an external organization, a militia, or the FARDC, using as baseline the effect on welfare of the price when no stationary bandit is present. Implementing this regression produces similar results.

[35]Table F.10 presents the results.

where W_{jt} is any indicator for household welfare, and SB_{jt} is a dummy indicating the presence of a stationary bandit, which can be defined to be of a particular type (militia, external, or FARDC). Estimating this equation through OLS, the coefficient γ_w can be interpreted as the effect of a given stationary bandit on household welfare if $E[\varepsilon_{jt}|SB_{jt}] = 0$. This assumption, however, is implausible, since stationary bandits likely select places where households are, or will become, richer. I tackle the endogeneity problem in the OLS framework in two ways. First, I include in all regressions controls for the, now familiar, price mineral interactions. This captures the endogenous location choices that are driven by mineral demand. Second, I also implement the specification with leads (SB_{jt+1}) and lags (SB_{jt-1}, SB_{jt-2}) for the independent variables.

Table 4, Panel A, presents the OLS estimation. Columns (1)-(4) implement specification 2 including as independent variables $Militia_{jt}$, $External_{jt}$, $Army_{jt}$, and using as dependent variables the household welfare outcomes of Table 3. The coefficient on $Militia_{jt}$ is positive and significant at the 5% and 1% level across the columns, indicating that having a stationary bandit from a militia increases the welfare index in .24 standard deviations. In contrast, the coefficient on external is negative and only significant for weddings. Finally, the coefficient on $Army_{jt}$ is positive and significant at the 1% in most columns, and indicates that having a stationary bandit from the Congolese army increases the household welfare index in .32 standard deviations. Importantly, a test of equality of coefficients rejects that the coefficient on $Militia_{jt}$ (or $Army_{jt}$) and the coefficient on $External_{jt}$ are equal, with p-value of 0, while the coefficients on $Militia_{jt}$ and $Army_{jt}$ are indistinguishable. Columns (5)-(7) use the index of household welfare as dependent variable, and include respectively only $Militia_{jt}$, $External_{jt}$, $Army_{jt}$, restricting the sample respectively to observations: with either a militia or no stationary bandit, with either an external stationary bandit or no stationary bandit, with wither a stationary bandit from the army or no stationary bandit. Coefficients thus capture the effect of a given stationary bandit over the alternative of no stationary bandit (and serve as comparison for the IV coefficients described next). The coefficients in columns (5)-(7) are also significant and positive for militia and the army, and negative and insignificant for external armed actors. The effects including leads and lags, reported in Table F.11, are identical, and leads are all insignificant.

IV: Since the OLS specification can be subject to other forms of endogeneity, I instrument for stationary bandit. In 2003, the major armed groups agreed to withdraw from their territories, as part of an all-inclusive agreement that arose as a result of significant political pressure to end the

Second Congo War (the Sun-City agreement). The timing of the agreement is linked to the build-up of political pressure, including reports by international observers about the deadliness of the war. As a result, by 2005, the RCD, the major consortium of external armed actors at the time, and regional militia had abandoned most municipalities (Marchais, 2016). If the peace agreement affected household welfare differentially only through the withdrawal of stationary bandits, the following two-stage least-squares using the targeted villages and those that had no stationary bandit in 2002 identifies the effect of having a stationary bandit of a given type:

$$First\ Stage : SB_{jt} = \eta_j + \gamma_t + bPOST_t * SB_j^{2002} + u_{jt}$$
$$Second\ Stage : W_{jt} = \alpha_j + \beta_t + a\hat{SB}_{jt} + \varepsilon_{jt}$$

where $POST_t$ indicates years on or after 2003, and SB_j^{2002} indicates whether a location was under the control of a stationary bandit (of a given type) in 2002. Coefficient a estimates the local average treatment effect for support villages that "comply"—where the stationary bandit leaves in response to the peace agreement (and would otherwise have stayed). The RCD was the only external group included in the agreement (and the largest). Thus, for this analysis, I code $External_{jt}$ as RCD. Villages with different types of stationary bandit in 2002 were similar (Figure F.10).

I follow the following steps support the causal interpretation of the estimating equation. First, since villages may be taken in response to their tax potential, I include controls for mineral endowments interacted with their prices in the baseline regressions regressions (adding the controls does not change the results). Second, since the coltan price shock of the year 2000 leads to a drastic reallocation followed by stability, I exclude years preceding the coltan boom, and I select the interval of years for the analysis among the remaining years as the one that maximizes the coefficient on $POST_t * SB_j^{2002}$ in the first stage for militia and external armed actors, [2002, 2011]. Compliance is respectively 82%, 91%, 87% for village militia, regional militia, and external stationary bandits and the F-test for the first stage model (Table F.12) is above 20 across the board (and is larger without price controls). Third, since the FARDC appears after 2005 and the FDLR (Hutu militia, excluded from the peace agreement) remains present, I also control for presence of the FARDC and the FDLR (adding these "bad" controls leaves the result unaffected). In addition, I examine whether the results are robust to restricting to the years in which the FARDC is absent [2002,2005]. Fourth, I replicate the analysis with treatment group time-trends.

Table 4, Panel B, presents the IV results. Columns (1)-(4) restrict the sample to support villages in which there is either a militia or no stationary bandit in 2002, and instruments the presence of a militia stationary bandit with $POST_t$ X SB_j^{2002}. Having a militia stationary bandit is associated with a welfare index higher by .71 standard deviations (column 4), significantly higher than the OLS coefficient of Panel A, column (5), and robust to the inclusion of time trends (Table F.13). Columns (5)-(8) restrict the sample to villages that have either an external stationary bandit (RCD) or no stationary bandit in 2002, and instruments the presence of an external stationary bandit with $POST_t$ X SB_j^{2002}. The coefficient on external stationary bandits is indistinguishable from zero (columns 5-8). Including time trends (Table F.13), the coefficient is positive and significant. However, it vanishes when I restrict to years [2002;2005]. As in the OLS results, militia lead to a robust increase in household welfare on net, external actors do not.[36]

5.4 Do households like stationary bandits?

Implicit association tests (IAT) provide additional support to the welfare results. In an additional survey round, surveyors administered an audio IAT, designed to measure the biases that (potentially illiterate) households have towards known armed groups, to a random sample of ten households in most of the 106 support villages of the Nord Kivu sample. Households played multiple rounds, which included cues for external armed actors (RCD, M23, FDLR, and the colonial state), the FARDC, and known popular militia (Raia Mutomboki, Mayi-Mayi). Results are shown in Figure F.13. Subjects have a significant and comparable negative bias towards external armed actors and the colonial state, and a positive bias towards popular militia, FARDC, and chiefs.

6 Intensification of the essential functions of a state

6.1 Explaining the intensification of the essential functions of a state

Table 2 (Panel C) also describes the intensive margin outcomes defined Section 2.4. The FARDC holds a (illicit) fiscal administration 16% of the years they are a stationary bandit in a village,

[36]Figure F.10 presents a balance test, Figure F.11 presents the composition of stationary bandits through the shock. Figure F.11 shows that in response to the peace agreement, militia and external armed actors withdraw. Furthermore, while the FARDC takes support villages in the aftermath, the proportion is negligible until 2005. Figure F.12 presents the reduced form. Welfare is consistently higher in militia municipalities, which appear shielded from the conflict. After 2003, the rest of municipalities catch up from lower welfare during the conflict. Table F.13 presents the results including treatment group time trends.

against 68% for external armed groups, 68% for regional militia, and 47% for village militia.

Table 5, Panel A, presents the results from specification 1, using as dependent variables the vector of "sophisticated" taxes in Columns (1) through (4) (poll taxes, food market taxes, toll booths at the village, mill tax), a tax sophistication index (Column 5), a dummy for fiscal administration at the village (Column 6), a dummy for justice administration at the village (Column 7), and an overall intensive margin index (Column 8).[37] The table indicates that the gold price leads to the rise of taxes on the food market at the village (Column 2), to an overall increase in tax sophistication (Column 5), to an increase in the likelihood that a stationary holds a fiscal administration (Column 6), and to an increase in the intensive index (Column 8). While the coltan price led stationary bandits to hold monopolies of violence at coltan mines, it also leads them to dismantle their administration at the support village—an "administration resource curse."

A specific selection problem applies, however, to the analysis of the intensive margin. Price shocks may change the composition of stationary bandits. Yet, as seen in Table 2 (Panel C), stationary bandits differ widely in their intensive margin "styles." To isolate the changes in stationary bandits' incentives and behavior from changes in their types, Panel B shows the results including stationary bandit organization fixed effects. Accounting for changes in composition significantly strengthens the results. Both effects are strengthened when I exclude the FARDC, and vanish when I keep only the FARDC, indicating that the effect is not driven by the FARDC.[38] Figure 5, Panels A (unconditional) and B (conditional), provides a graphical representation.[39]

[37]The tax sophistication index (top row) was constructed as follows. First, for each tax instrument $i \in \{1, N\}$, for all years t and villages j in which a stationary bandit uses it, I compute the proportion of observations in which the stationary bandit holds a fiscal administration. This yields a weight $w_i \in \{0, 1\}$ for each tax that proxies for the degree to which tax instrument i is associated with investments in fiscal administration. A high w_i thus indicates that tax i is associated with a high cost of collection. Then, for each tax vector observed at year t in village j, I compute the following weighted average: $I_{jt} = \sum_{i=N}^{i=1} = w_i T_{ijt}$, where w_i are the tax instrument weights and T_{it} is a dummy indicating whether tax i is collected at time t in village j. For interpretation purposes, I then normalize I_{jt} by subtracting its mean and dividing by its standard deviation: $I_{jt}^{normalized} = \frac{I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}}{\sqrt{\frac{1}{n}\sum_j \sum_t \left(I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}\right)^2}}$. I also construct an administrative development using principal component analysis for ordinal scale items on village fiscal administration, village justice administration. As with the tax sophistication index, I then normalized to units of standard deviation centered around the mean. I use both the tax sophistication index and the administrative development index to compute an overall intensive margin index, which I use in column (8). Such index is constructed using principal component analysis for ordinal scale items on the tax sophistication variable and the administration index variable, normalized to mean zero and standard deviation of one.

[38]Tables F.15 and F.16 present the results excluding the FARDC, and excluding all other stationary bandits.

[39]The results remain in 12 out of 13 robustness tests, presented in Table F.14. The null that the coefficient is zero fails to be rejected in the Arellano-Bond estimation, although it remains when including the lagged dependent.

6.2 What else do stationary bandits do?

Stationary bandits intensify the essential functions of a state in deeper ways than those contemplated in the testable implications of section 2.4. First, in approximately 60% of episodes, the stationary bandit has developed formal documents and seal. Second, they occasionally create local markets and regulate local businesses in 6% of episodes. Third, they run propaganda campaigns aimed at acquiring legitimacy in 41% of episodes and conduct initiation rituals in 29% of episodes. Furthermore, in 17% of episodes, they conduct witch-hunts to crush opposed spiritual leaders so as to maintain the endorsement of the guardians of local belief systems. Finally, while they replace traditional chiefs in 55% of episodes, they create indirect rule with local chiefs in the rest.[40] What explains that they attempt or succeed to have legitimacy, and the design of their political institutions is left for further research (Henn et al., 2018).

7 Conclusion

While they can be arbitrarily violent, armed actors often establish a monopoly of violence, tax and provide protection if there is a surplus they can expropriate—creating the essential functions of a state. When it is profitable to do so, armed actors may then intensify such functions by creating a fiscal administration, by sophisticating their taxation practices, and by administering justice.

When the stationary bandits are legitimate could be better understood. When lacking legitimacy, armed actors often use local intermediaries. Both open questions can account for variations in state formation that are beyond this paper's goal.

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[40] See Table F.1 and Figures F.14, F.15, F.16, and F.17 in the online appendix for additional details.

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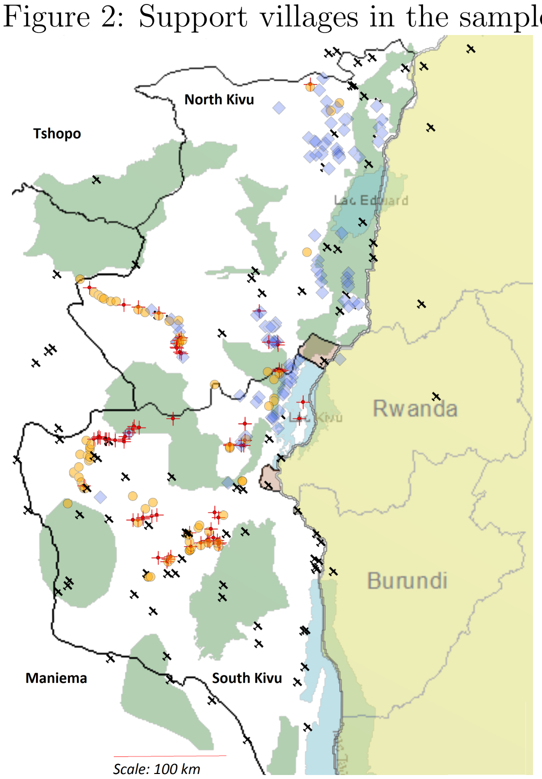
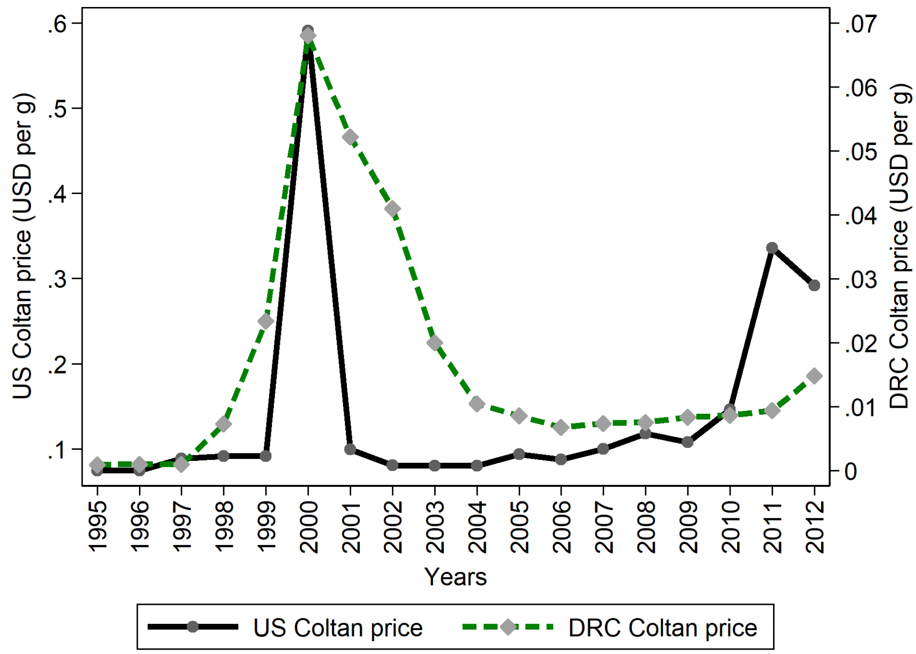
Figure 2: Support villages in the sample



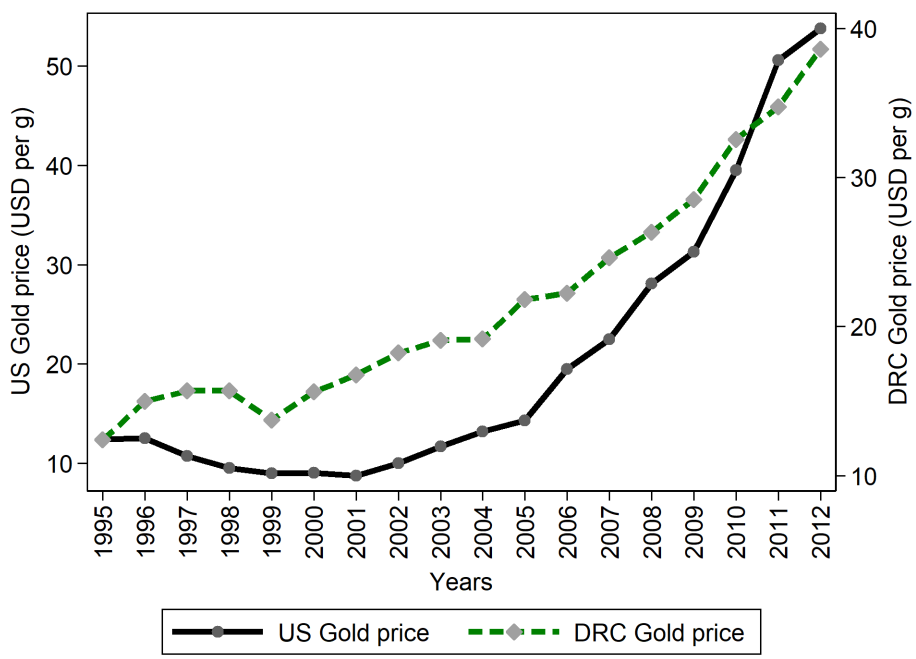
Notes: This map presents the location of the support villages. Support villages with at least one coltan mine are marked with a cross (red). Support villages with at least one gold mine are marked with a (golden) disk. Support villages with neither gold nor coltan mines are marked with a (purple) diamond. The economy of such municipalities is based on the following cash crops: coffee, cacao, beans, or on less prevalent minerals in the sample (cassiterite and tungsten), and for a small sample, subsistence agriculture (Kalehe). Planes indicate local airstrips.

Figure 1: Prices of coltan and gold in the US and the DRC

PANEL A: Price of coltan

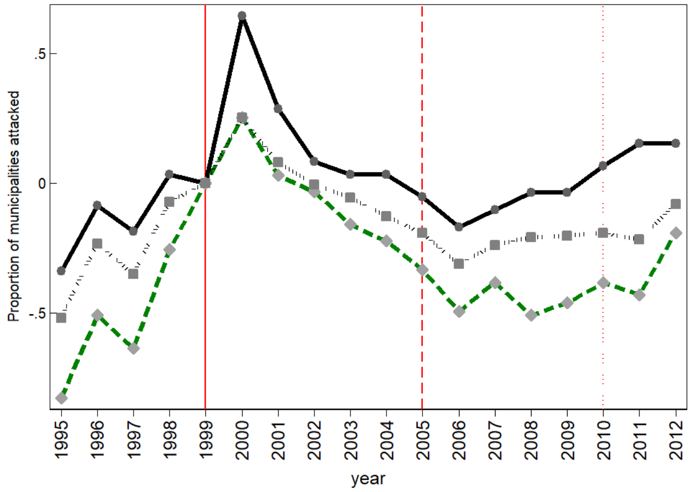


PANEL B: Price of gold



Notes: This figure plots the yearly average price of coltan and gold in the US and in the DRC, in US Dollars per gram. Panel A shows the prices of coltan. Panel B shows prices of gold. Source: US prices are taken from United States Geological Survey (2016) and DRC prices are from this study's survey and are collected using recall. The price of gold in DRC is at times higher than the US price, reflecting measurement error from recall data.

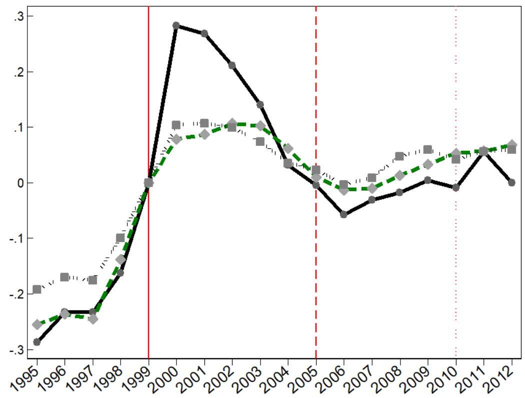
Figure 3: Conflict—violent attacks



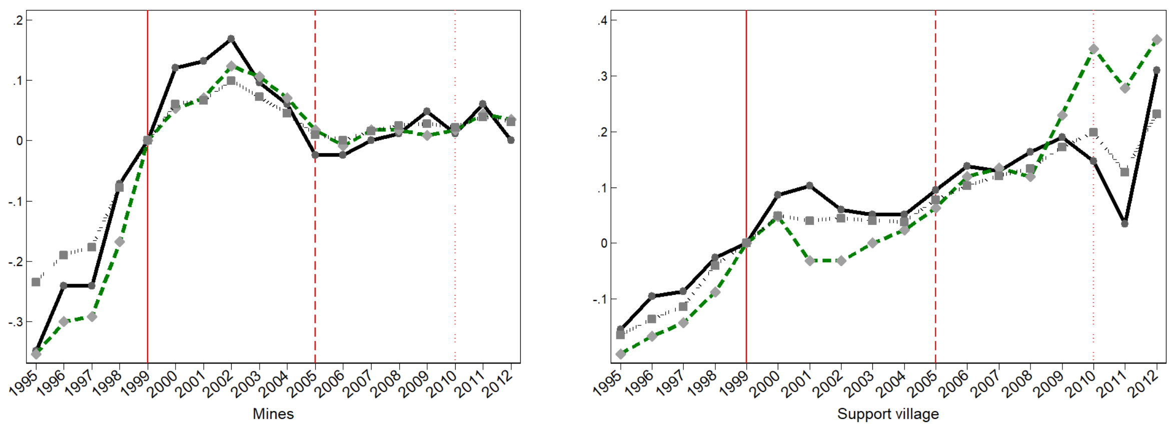
Notes: This figure presents the proportion of municipalities that are subject to an attack through the years in the sample through the years in the sample. The solid and the dashed times-series lines respectively indicate the proportions for coltan locations and gold locations. The dotted times-series line marks the proportion of locations endowed with any other resource (including the matched subsistence agriculture sample of Kalehe). A location that is a mine is coded as coltan if it is endowed with coltan, and similarly for gold. A location that is a mine is coded as other if the mines in its municipality have neither gold nor coltan. A locations that is a support village is coded as coltan if at least one mine in its municipality has coltan, and similarly for gold. A locations that is a support village is coded as other if its municipality has neither gold nor coltan mines. The proportions are expressed in deviations from 1999 levels. The red solid vertical line indicates 1999, the year preceding the major coltan shock. The red dashed vertical line indicates 2005, the year preceding the completion of the post-war transition of military actors. The red dotted vertical line indicates 2010, the year preceding the second, smaller, coltan shock (which, as seen from Figure 1 had a neglibible effect on local prices).

Figure 4: Explaining the rise of taxes on production, stationary bandits, and protection

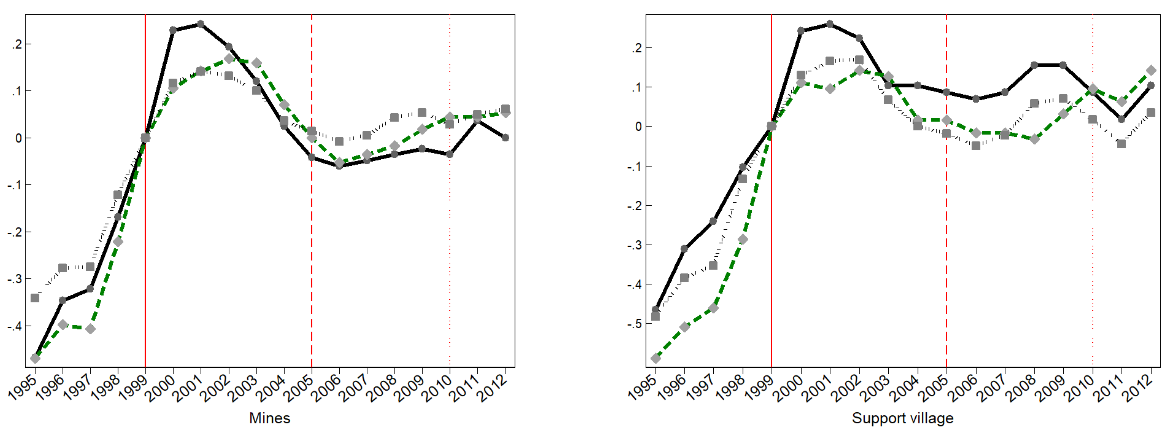
PANEL A: Taxes on mineral production



PANEL B: Security service



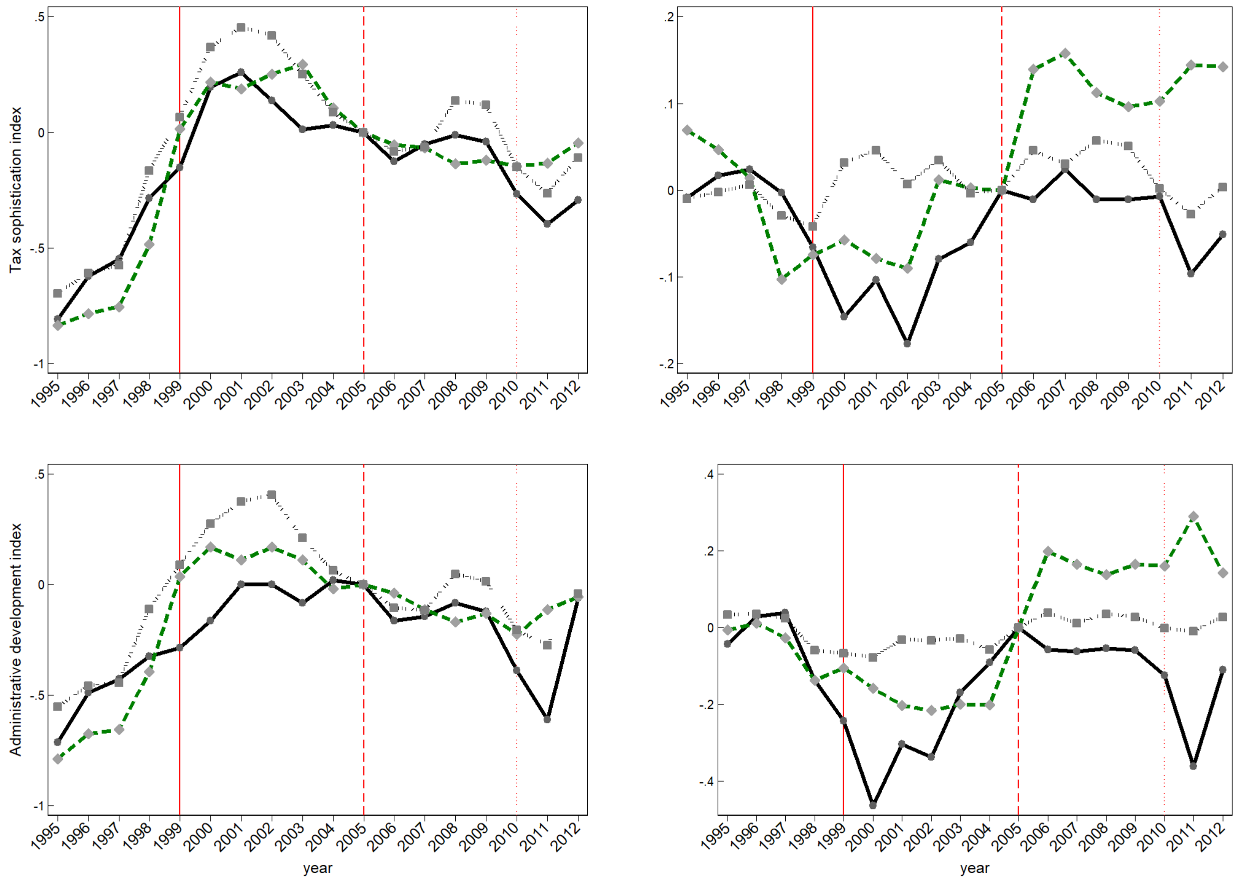
PANEL C: Stationary bandit



Notes: This figure presents the extensive margin of the essential functions of a state: taxation, monopoly of violence, and protection. Rows 1,2, and 3 present respectively the proportion of sites where stable taxation exists, where a bandit holds a monopoly of violence, and where an armed actor provides security. Panel A presents the outcomes at the mine, and Panel B presents the outcomes at the support village. The solid and the dashed times-series lines respectively indicate the proportions for coltan sites and gold sites. The dotted times-series line marks the proportion of locations endowed with any other resource (including the matched subsistence agriculture sample of Kalehe). A mine is coded as coltan if it is endowed with coltan, and similarly for gold. A mine is coded as other if the mines in its municipality have neither gold nor coltan. A support village is coded as coltan if at least one mine in its municipality has coltan, and similarly for gold. A support village is coded as other if its municipality has neither gold nor coltan mines. The proportions are expressed in deviations from their 1999 levels. The red solid vertical line indicates 1999, the year preceding the major coltan shock. The red dashed vertical line indicates 2005, the year preceding the completion of the post-war transition of military actors. The red dotted vertical line indicates 2010, the year preceding the second, smaller, coltan shock (which, as seen from Figure 1 had a neglibible effect on local prices).

Figure 5: Explaining the intensification of the essential functions of a state

Panel A: Unconditional **Panel B:** Conditional



Notes: This figure presents the intensive margin of the essential functions of a state: fiscal sophistication and administration. Panel A shows the unconditional fiscal sophistication index and administrative development index (and thus reflects the change in stationary bandits' behavior as well as the change in composition of stationary bandits). The fiscal sophistication index (top row) was constructed as follows. First, for each tax instrument $i \in \{1, N\}$, for all years t and villages j in which a stationary bandit uses it, I compute the proportion of observations in which the stationary bandit holds a fiscal administration. This yields a weight $w_i \in \{0, 1\}$ for each tax that proxies for the degree to which tax instrument i is associated with investments in fiscal administration. A high w_i thus indicates that tax i is associated with a high cost of collection. Then, for each tax vector observed at year t in village j, I compute the following weighted average: $I_{jt} = \sum_{i=N}^{i=1} = w_i T_{ijt}$, where w_i are the tax instrument weights and T_{it} is a dummy indicating whether tax i is collected at time t in village j. For interpretation purposes, I then normalize I_{jt} by substracting its mean and dividing by its standard deviation: $I_{jt}^{normalized} = \frac{I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}}{\sqrt{\frac{1}{n}\sum_j \sum_t \left(I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}\right)^2}}$. The administration index (bottom row) was constructed using principal component analysis for ordinal scale items on the following two dummies: village fiscal administration, village justice administration. As with the tax sophistication index, I then normalized to units of standard deviation centered around the mean. Panel B shows the conditional time series. In particular, I first regress the fiscal sophistication index and administrative development index on to dummies indicating each armed group organization, and use the residual. This procedure thus accounts for changes in the outcomes that may be due to changes in armed organization composition, a major concern after the Second Congo War. The times series thus reflects only changes in stationary bandit behavior, holding constant their particular armed group style. The solid line and the dashed line respectively indicate the proportions for coltan sites and gold sites. The dotted line marks the proportion of locations endowed with any other resource (including the matched subsistence agriculture sample of Kalehe). A support village is coded as other if its municipality has neither gold nor coltan mines. The proportions are expressed in deviations from their 2005 levels, the first year after the Second Congo War, which ended in drastic changes in composition.

Table 1: Explaining the rise of taxes on production, stationary bandits, and protection

VARIABLES	(1) **Attack Mun.**	(2) **Customs Tax Mine**	(3) **Entry Fees Mine**	(4) **Stationary Bandit Mine**	(5) **Security Service Mine**	(6) **Extensive Index Mine**	(7) **Stationary Bandit Village**	(8) **Security Service Village**	(9) **Extensive Index Village**
Coltan(j) X pc(t)	0.20***	0.06**	0.01	0.07***	0.06**	0.16***	0.04	0.02	0.07
	(0.06)	(0.02)	(0.02)	(0.03)	(0.02)	(0.06)	(0.03)	(0.02)	(0.05)
Gold(j) X pg(t)	-0.06	-0.04	0.04*	0.05	0.05	0.10	0.12***	0.15***	0.33***
	(0.06)	(0.02)	(0.03)	(0.04)	(0.04)	(0.07)	(0.04)	(0.04)	(0.08)
Observations	4,158	4,046	4,052	3,991	4,032	3,903	4,302	4,302	4,302
R-squared	0.44	0.59	0.69	0.60	0.62	0.65	0.50	0.42	0.50

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1 using as dependent variables the extensive margin outcomes. Column (1) uses as dependent variable whether the municipality was attacked in a given year (in any of its mines or its support village, by any actor). Columns (2) through (6) show the outcomes at the production site (mine), and columns (7) through (9) at the support village corresponding to the mine. Column (2) uses a dummy indicating whether an armed actor imposed customs taxation on mining output at the exit of the mine (enforced through a roadblock). Column (3) uses a dummy indicating whether an armed actor imposed an entry fee to work at the mine (enforced through a roadblock). Column (4) uses a dummy indicating whether an armed actor had established a monopoly of violence at the mine. Column (5) uses a dummy indicating whether an armed actor provided a security service at the mine. Column (6) uses the extensive margin index at the mine as dependent variable. The extensive margin index at the mine is constructed as the mean of customs taxation, entry fees, stationary bandit, and security service, normalized to mean zero and standard deviation of one. Column (7) uses instead a dummy indicating whether an armed actor had established a monopoly of violence at the support village corresponding to the mine. Column (8) uses a dummy indicating whether an armed actor provided a security service at the support village corresponding to the mine. Column (9) uses the extensive margin index at the support village as dependent variable. The extensive margin index at the support village is constructed as the mean of stationary bandit and security service at the village, normalized to mean zero and standard deviation of one. There are 239 municipalities in the sample, broken down into 239 support villages, and their corresponding 411 mining sites. The mine*year level data is collapsed at the municipality-year level. All columns include year and municipality level fixed effects. Standard errors are clustered at the level of the municipality to account for autocorrelation in the dependent variable, the mineral endowments (which are time invariant), and the mineral price. Section E in the online appendix describes 13 robustness checks. The results are presented in Tables F.2, F.5, F.6 and Figures F.5, F.4, F.6, F.7, F.8. Table F.7 and Figure F.9 show the effect of the price shocks on the composition of stationary bandits. Table F.8 shows the results excluding the FARDC and Table F.9 shows the results including only the FARDC.

Table 2: Who are the stationary bandits?

PANEL A: STATIONARY BANDIT'S TYPE

	Support Village episodes #	**Co-ethnicity Chief** members %	**Seen as Legitimate** episodes %
External groups	229	19	17
Army (FARDC)	159	18	69
Regional militia	115	29	20
Village militia	112	93	75

PANEL B: ARMED ACTOR ATTACKS, BY TYPE

		Type			**Crimes**		
	#	Conquest %	Sanction %	Pillage %	Sexual viol. %	Kindap %	Death %
External groups	556	36	28	72	58	56	61
Army (FARDC)	52	46	37	39	37	16	44
Regional militia	309	50	42	53	33	35	50
Village militia	2	0	0	50	0	0	50

PANEL C: STATIONARY BANDIT'S ACTIONS, BY TYPE (% years)

	Mine			**Support village**						
	Customs Taxation	**Entry Fees**	**Security Service**	**Security Service**	**Poll Tax**	**Toll Tax**	**Sales Tax**	**Mill Tax**	**Fiscal Adm.**	**Judicial Adm.**
External groups	46	33	62	29	80	52	49	16	68	70
Army (FARDC)	33	38	69	72	46	33	23	10	16	28
Regional militia	66	55	62	28	82	38	49	10	68	69
Village militia	22	47	67	59	85	43	45	31	47	49
	extensive			extensive	intensive					

Notes: This table presents the classification of stationary bandits into village militias, regional militias, Congolese army (FARDC), and external organizations. Panel A decomposes stationary bandit episodes that are observed at the support village in this survey, and shows key characteristics linked to the origin and acceptance of the stationary bandit. The percentage of members co-ethnic with chief is calculated by gathering the ethnicity of the top 5 members of the stationary bandit unit at the village. The column "seen as legitimate" is the average household-level response, extracted in household interviews about each corresponding stationary bandit episode in the village as the answer to the following question: "Did you consider that the stationary bandit was legitimate in your view?" Both co-ethnicity and "perception of legitimacy" were only collected in the second phase of the survey (only in the 106 support villages of Nord Kivu). Panel B shows the attacks recorded in the survey, by type of armed actor. These attacks are mostly perpetrated by armed actors who are not stationary bandits in the location where the attack takes place, but they may be stationary bandit in another location. Panel C shows the extensive and margin actions of each stationary bandit type. Source: this paper's survey, support village level data. The classification is constructed as follows. Village militias emerge in the municipality as a popular mobilization. Regional militias are popular mobilizations that emerge in the region, but not in the municipality. Regional militias include many former village militias, including Mayi-Mayi factions — Janvier, Kaganga, Kasingie, Kifuafua, Padiri, Lafontaine, Lulwako, Mudohu, Katalayi, Mze, Nyakiliba, Sim, Samy, Surambaya — Raia Mutomboki (all factions), Nyatura, Batiri, Katuku, and Mbaire. External organizations are not from the area and are most often "foreign" ethnic groups. External organizations include the Tutsi-dominated RCD, CNDP, AFDL, M23, and PARECO, the Hutu-dominated FDLR (including FDLR Tanganyika) and Interahamwe, as well as other groups, such as ADF-NALU.

Table 3: Essential functions of a state and household welfare—Heterogeneous effect of prices

Panel A: Coltan price

VARIABLES	(1) **Savings index**	(2) **Weddings number**	(3) **Immigrants number**	(4) **Welfare index**
Coltan(j) X pc(t)	0.08*	0.23***	0.54***	0.36***
	(0.05)	(0.08)	(0.16)	(0.08)
C(j) X pc(t) X SB(jt)	-0.01	0.01	0.01	0.02
	(0.01)	(0.02)	(0.04)	(0.02)
C(j) X pc(t) X SB(jt) X Army(jt)	-0.01	0.02	0.03	0.03
	(0.01)	(0.02)	(0.05)	(0.03)
C(j) X pc(t) X SB(jt) X Militia(jt)	0.02**	0.08***	0.17***	0.11***
	(0.01)	(0.02)	(0.04)	(0.03)
Observations	3,582	3,466	3,523	2,669
R-squared	0.36	0.54	0.40	0.52

Panel B: Gold price

VARIABLES	(1) **Savings index**	(2) **Weddings number**	(3) **Immigrants number**	(4) **Welfare index**
Gold(j) X pg(t)	-0.08	-0.01	-0.07	-0.06
	(0.05)	(0.09)	(0.14)	(0.09)
G(j) X pg(t) X SB(jt)	-0.00	-0.02	-0.04*	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)
G(j) X pg(t) X SB(jt) X Army (jt)	0.00	0.04**	0.09***	0.04***
	(0.01)	(0.02)	(0.02)	(0.01)
G(j) X pg(t) X SB(jt) X Militia(jt)	0.00	0.03**	0.08***	0.03**
	(0.01)	(0.01)	(0.02)	(0.01)
Observations	3,582	3,466	3,523	2,669
R-squared	0.36	0.53	0.39	0.50

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1 at the support village (where households are located), disaggregated by whether the support village was under a monopoly of violence held by an external armed actor, the FARDC, or a militia, which pools village and regional militia. Since a stationary bandit ($SB_{jt} = 1$) is either affiliated to a militia ($Militia_{jt} = 1$), to the FARDC ($Army_{jt} = 1$), or to an external organization ($External_{jt} = 1$), $SB_{jt} = Militia_{jt} + External_{jt} + Army_{jt}$. Thus the additional effect of having an external stationary bandit, a stationary bandit from a (regional or village) militia, or a stationary bandit from the FARDC can be read respectively on the coefficients on the interaction that includes only SB_{jt}, $Militia_{jt}$ X SB_{jt}, and $Army_{jt}$ X SB_{jt}. Panel A presents the results for the coltan price and Panel B for the gold price. Column (1) presents the standardized (mean zero, standard deviation of one) household index for savings/investment. It uses as dependent variable an index that uses variables collected at the household level in the random sample of households in each village. For these variables, only household respondents who were settled in the village before 2000 were included to control for compositional effects due to migration. The data of these households is then collapsed at the household*year level to reduce concerns of within village*year intra-cluster correlation. Column (2) uses as dependent variable the logarithm of the number of weddings (plus one). Column (3) presents the effects on the log of the number of migrants (plus one). Column (4) uses a standardized welfare index (mean zero, standard deviation of one), constructed using principal components of the household savings index, the logarithm of weddings, and the logarithm of the number of immigrants. The FARDC was absent prior to 2005, which is the time period when the coltan shock takes place. All regressions include year fixed effects and municipality fixed effects. Standard errors are clustered at the level of the municipality. Table F.10 presents results with controls for time-varying effects of a location suitability for a stationary bandit.

Table 4: Essential functions of a state and household welfare—Effect of stationary bandits

Panel A: OLS

VARIABLES	(1) Savings index	(2) Weddings number	(3) Immigrants number	(4) **Welfare index**	(5) **Welfare index**	(6) **Welfare index**	(7) **Welfare index**
Militia(jt)	0.05**	0.16**	0.46***	0.24***	0.20***		
	(0.02)	(0.06)	(0.11)	(0.06)	(0.07)		
External(jt)	0.03	-0.20***	-0.13	-0.07		-0.04	
	(0.03)	(0.06)	(0.11)	(0.06)		(0.07)	
Army(jt)	0.03	0.25***	0.42***	0.32***			0.48***
	(0.04)	(0.08)	(0.14)	(0.08)			(0.12)
Observations	3,582	3,466	3,523	2,669	1,426	1,579	1,474
R-squared	0.36	0.54	0.40	0.51	0.63	0.63	0.63
Sample restriction	NO	NO	NO	NO	YES	YES	YES

Panel B: IV (2SLS)

VARIABLES	(1) Savings Index	(2) Weddings Number	(3) Immigrants Number	(4) **Welfare index**	(5) Savings Index	(6) Weddings Number	(7) Immigrants Number	(8) **Welfare index**
SB(jt)	0.01	0.26	1.70***	0.71***	-0.04	-0.28**	0.97***	0.25
	(0.09)	(0.18)	(0.45)	(0.21)	(0.08)	(0.13)	(0.35)	(0.19)
Observations	1,230	1,341	1,339	1,035	1,330	1,485	1,396	1,111
Number of clusters	123	153	152	121	133	161	158	129
Type	MIL	MIL	MIL	MIL	EXT	EXT	EXT	EXT

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the OLS and 2SLS estimates for the effect of different types of stationary bandits on household welfare. Standard errors are clustered at the level of the municipality. All regressions include year fixed effects, municipality fixed effects, and controls for $p^{US}_{c,t}$ and $p^{US}_{g,t}$. The results are unchanged excluding such controls. Panel A presents the OLS results. Columns (1)-(4) implement specification 2 including as independent variables $Militia_{jt}$, $External_{jt}$, $Army_{jt}$, and respectively using as dependent variables the savings index, the number of celebrated weddings, the number of immigrants, and the index of household welfare. Columns (5)-(7) use the index of household welfare as dependent variable, and include respectively only $Militia_{jt}$, $External_{jt}$, $Army_{jt}$, restricting the sample respectively to: observations with either a militia or no stationary bandit, observations with either an external stationary bandit or no stationary bandit, observations with wither a stationary bandit from the army or no stationary bandit. Coefficients are thus to be interpreted as the effect of a given stationary bandit over the alternative of no stationary bandit, and serve as comparison for the IV coefficients of Panel B. The contemporaneous effects including leads and lags, reported in Table F.11, are identical, and leads are all insignificant. Panel B presents the 2SLS coefficients, which are estimated by instrumenting $SB(jt)$ (once for militia, then for external stationary bandits) with $POST_t$ X $TARGET_j$. The dummy $SB(jt)$ indicates the presence of a (militia, then external) stationary bandit. Columns (1)-(4) restrict the sample to support villages in which there is a militia stationary bandit in 2002 plus support villages in which there is no stationary bandit in 2002. Presence of a militia stationary bandit ($SB(jt)$) is instrumented with the variable $POST_t$ X $SB, Militia^{2002}_j$. Columns (5)-(8) restrict the sample to support villages in which there is an external stationary bandit in 2002 plus support villages in which there is no stationary bandit in 2002. Presence of an external stationary bandit ($SB(jt)$) is instrumented with the variable $POST_t$ X $SB, External^{2002}_j$. Columns (1) and (5) present the standardized (mean zero, standard deviation of one) household index for savings/investment. They use as dependent variable an index that uses variables collected at the household level in the random sample of households in each village. For these variables, only household respondents who were settled in the village before 2000 were included to control for compositional effects due to migration. The data of these households is then collapsed at the household*year level to reduce concerns of within village*year intra-cluster correlation. Columns (2) and (6) use as dependent variable the logarithm of the number of weddings (plus one). Columns (3) and (7) present the effects on the log of the number of migrants (plus one). Columns (4) and (8) use a standardized welfare index (mean zero, standard deviation of one), constructed using principal components of the household savings index, the logarithm of weddings, and the logarithm of the number of immigrants. Figure F.10 provides a balance test, Figure F.11 (and Table F.12) presents the first stage, and provides a graphical representation of the reduced form results is provided in Figure F.12. Table F.13 presents the results with target group time trends (targed groups are defined by $SB, Militia^{2002}_j = 1$ and $SB, External^{2002}_j = 1$).

Table 5: Explaining the intensification of the essential functions of a state

PANEL A: Unconditional

VARIABLES	(1) **Poll Tax**	(2) **Market Tax**	(3) **Toll Booth**	(4) **Mill Tax**	(5) **Tax Index**	(6) **Fiscal Admin**	(7) **Justice Admin**	(8) **Intensive Index**
Coltan(j) X pc(t)	0.02	-0.03**	-0.00	-0.00	-0.02	-0.05**	-0.05**	-0.07
	(0.03)	(0.02)	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.04)
Gold(j) X pg(t)	0.04	0.07**	0.05	-0.01	0.13*	0.07**	0.06	0.16**
	(0.05)	(0.03)	(0.04)	(0.02)	(0.08)	(0.03)	(0.04)	(0.07)
Observations	4,302	4,289	4,302	4,302	4,289	4,302	4,302	4,289
R-squared	0.43	0.48	0.50	0.45	0.48	0.50	0.48	0.51

PANEL B: Conditional

VARIABLES	(1) **Poll Tax**	(2) **Market Tax**	(3) **Toll Booth**	(4) **Mill Tax**	(5) **Tax Index**	(6) **Fiscal Admin**	(7) **Justice Admin**	(8) **Intensive Index**
Coltan(j) X pc(t)	0.00	-0.04**	-0.00	-0.00	-0.05	-0.08***	-0.08***	-0.12***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.03)	(0.02)	(0.02)	(0.03)
Gold(j) X pg(t)	0.03	0.07**	0.05	0.00	0.11*	0.09***	0.07**	0.16***
	(0.04)	(0.03)	(0.04)	(0.02)	(0.06)	(0.03)	(0.03)	(0.06)
Observations	4,257	4,244	4,302	4,257	4,244	4,257	4,257	4,244
R-squared	0.72	0.61	0.50	0.52	0.76	0.71	0.70	0.81

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1 using as dependent variables the vector of "sophisticated" taxes in Columns (1) through (4) (poll taxes, food market taxes, toll booths at the village, mill tax), a tax sophistication index (Column 5), a dummy for fiscal administration at the village (Column 6), a dummy for justice administration at the village (Column 7), and an overall intensive margin index (Column 8). The fiscal sophistication index (top row) was constructed as follows. First, for each tax instrument $i \in \{1, N\}$, for all years t and villages j in which a stationary bandit uses it, I compute the proportion of observations in which the stationary bandit holds a fiscal administration. This yields a weight $w_i \in \{0, 1\}$ for each tax that proxies for the degree to which tax instrument i is associated with investments in fiscal administration. A high w_i thus indicates that tax i is associated with a high cost of collection. Then, for each tax vector observed at year t in village j, I compute the following weighted average: $I_{jt} = \sum_{i=N}^{i=1} = w_i T_{ijt}$, where w_i are the tax instrument weights and T_{it} is a dummy indicating whether tax i is collected at time t in village j. For interpretation purposes, I then normalize I_{jt} by subtracting its mean and dividing by its standard deviation: $I_{jt}^{normalized} = \frac{I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}}{\sqrt{\frac{1}{n}\sum_j \sum_t \left(I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}\right)^2}}$. The overall intensive margin index is constructed using principal component analysis for ordinal scale items on the tax sophistication variable and an index of administrative development, and the outcome is then normalized to mean zero and standard deviation of one. The index of administrative development is constructed principal component analysis for ordinal scale items on the following two dummies: village fiscal administration, village justice administration. As with the other indexes, I then normalized to units of standard deviation centered around the mean. To separate selection effects induced by a change in composition from changes of stationary bandits' behavior, Panel B shows the results including stationary bandit organization fixed effects. For the conditional analysis, identification stems from changes in intensive margin outcomes within organizations, within village, across time. All regressions include year fixed effects, municipality fixed effects, and standard errors are clustered at the level of the municipality. Section E reports the results of 13 robustness tests. The results, presented in Table F.14, are robust to these tests (except for one). Table F.15 presents the results excluding the Congolese army (FARDC), and Table F.16 presents the results including only the FARDC.

Online Appendix

A Model

This section presents the model that produces the testable implications of section 2.4.

A.1 Stationary bandits and taxation in a production economy

In this section, I present the model of the production economy, which applies to the mines.

First, I present the general taxation problem of a stationary bandit. I derive its optimal tax and then use it to characterize the effect of an increase in the output price on the tax revenues as a stationary bandit when he/she is taxing at the optimal rate and, ultimately, the value of choosing to become a stationary bandit when no other armed actors can also become stationary bandit. In this problem, the stationary bandit is a first mover and there is perfect commitment to the tax plan he/she announces.

Second, I endogenize perfect commitment. Now, after workers have supplied labor and produced output, stationary bandits need to be given incentives not to renege on their taxation plan and instead expropriate all of the output. This extension allows to examine how an increase in the output price, interacts with the conditions that sustain taxation, and ultimately the feasibility of a stationary bandit.

Third, returning to the perfect commitment case, I relax the assumption that only one armed actor can contest the monopoly of violence, thus introducing the possibility of contestation. The extension shows that higher prices will lead to more conflict aimed at acquiring the monopoly of violence, but also to the emergence of a stationary bandit. It further produces a sorting implication: the rise in prices disproportionately benefits strong armed actors (in the sense that they can better defend a monopoly of violence) over weaker.

Fourth, I endogenize the revenue as a roving bandit, allowing it to also depend on the output price. In the general model, I have focused only on the tax revenues of a stationary bandit, but its outside option to be roving may also be affected. The extension shows that, under general conditions, the value of becoming a stationary bandit rises disproportionately over the value of becoming a roving bandit, but that this result depends on the underlying level of insecurity of property rights and the ability to hide output. For simplicity, I assume entry into banditry is a long-term choice, and an armed actor decision to become stationary bandit has an insignificant effect on the number of roving bandits in the area.[41]

A.1.1 General model of stationary bandit taxation

A mine is composed of k identical miners. Miners are partial residual claimants, and sell their output in the world markets at exogenous price p_i per unit of output.

Timing is as follows. First, miners choose, in n sectors $i = 1, 2, \ldots, n$, the amount of labor supply (e_i) and the amount of labor to hide (e_i^H), where $E^i\left(e_i^H, p_i\right)$ is the cost of concealing e_i^H units of labor and is continuously differentiable, monotonically increasing in e_i^H ($E_1^i > 0$) and strictly convex ($E_{11}^i > 0$). Second, output is revealed. Output in sector i, $\tilde{Y}_i$, is a function of the (stochastic, and ex-ante unknown) real labor productivity in sector i, $\tilde{\alpha}_i$, and the miners' labor supply, e_i: $\tilde{Y}_i = \tilde{\alpha}_i e_i$. The vector of labor real productivities, $\tilde{\alpha} \in R^n$, has a known probability density function $f(\tilde{\alpha})$. Third, miners choose the amount of output to conceal (H_i), conditional on labor supplied and hidden and conditional on the productivity realization, where $G^i(H_i, p_i)$ is the cost of concealing H_i units of output. $G^i(H_i, p_i)$ is differentiable, monotonically increasing in both arguments, ($G_1^i > 0$, $G_2^i > 0$) and strictly convex in H_i ($G_{11}^i > 0$). Fourth, roving bandits expropriate all the output of miners with probability 1, if they arrive in the village. Concealed output and labor cannot be expropriated. Labor cannot be expropriated by roving bandits. The value of output observable to roving bandits is $\tilde{y}_i = (\tilde{\alpha}_i e_i - H_i)\, p_i$ and observable labor is $\tilde{e}_i = e_i - e_i^H$. Bernoulli utility function and dis-utility from labor are monotonically increasing in their arguments. Miners' Bernoulli utility is concave in the unique consumption good, and the dis-utility from labor, $c(e)$, is separable across sectors and convex in each sector labor supply, where $e = \sum_{i=1}^{n} e_i$.

One armed actor has a higher endowment of "guns" than roving bandits, so that, if he wished to do so, he could sustain a monopoly of violence at a fixed cost F.[42] The armed actor can choose to impose his monopoly of violence in the mine, which gives him the option to offer a credible

[41] The extension provides testable implications useful for further research. It would be valuable, for instance, to endogenize the degree of insecurity as a function of endogenous entry into roving and stationary banditry, and characterize the equilibrium. This general equilibrium effect is beyond the scope of this paper.

[42] I henceforth follow the notation of "he" for the roving bandit because of the empirical observed regularity that they tend to be male in Eastern DRC.

expropriation plan with perfect commitment.[43] He becomes a Stackelberg leader, miners being uncoordinated followers. If he chooses instead to refrain from being a first mover, miners anticipate that the armed actor will expropriate all of the unhidden output he can expropriate in the last step if he remains in the mine.

When he moves first and there is perfect commitment, the armed actor is a "stationary bandit" and announces how much he plans to steal so as to maximize his revenue, internalizing the labor supply and concealing responses of miners. In particular, the stationary bandit can tax output and labor, using respectively the taxes $\tau = (\tau_1, \tau_2, \ldots, \tau_n)$, and $t = (t_1, t_2, \ldots, t_n)$. With a stationary bandit, timing is as follows. First, the stationary bandit presents an expropriation plan (the tax rates). Second, miners supply and conceal labor. Third, productivity is revealed. Fourth, miners choose how much output to conceal. Fifth, the stationary bandit expropriates following the tax rates he had announced as a first mover with commitment.

The solution to the miners' problem can be expressed as the functions: $e_i^*(\mathbf{p}, \tau, t)$, $e_i^{H*}(p_i, t_i)$, $H_i^*(p_i, \tilde{\alpha}_i, e_i, \tau_i)$. The miners take as given the stationary bandit's taxation plan, and first choose the amount of labor to supply and to conceal, then observe the realization of output, and only then choose the amount of output to conceal. By backward induction, this problem is solved in two steps. We assume that $G_1(0, p_i) = E_1(0, p_i) = c'(e) = 0$ and $\tilde{\alpha} \in R_+^n$, thus the optimal choice of $e_i^*(p, F_\alpha, \tau, t)$, $e_i^{H*}(p_i, t_i)$, $H_i^*(p_i, \tilde{\alpha}_i, e_i, \tau_i)$ is always strictly positive.

First, the miners choose the output concealing schedule, that is, the amount of output to conceal for each realization of productivity, for each amount of labor supplied and concealed, and for each taxation plan. The miners first solve, for each $\tilde{\alpha} \in R_+^n$:

$$\begin{array}{ll} \max\limits_{H} & u\left(\sum\limits_{i=1}^{N} \left((1-\tau_i)\, p_i \tilde{\alpha}_i e_i + \tau_i p_i H_i - t_i \tilde{e}_i - G^i(H_i, p_i) - E^i\left(e_i^H, p_i\right)\right)\right) - c(e) \\ \text{s.t.} & H_i \leq \tilde{\alpha}_i e_i,\ i = 1, 2, \ldots, N \end{array}$$

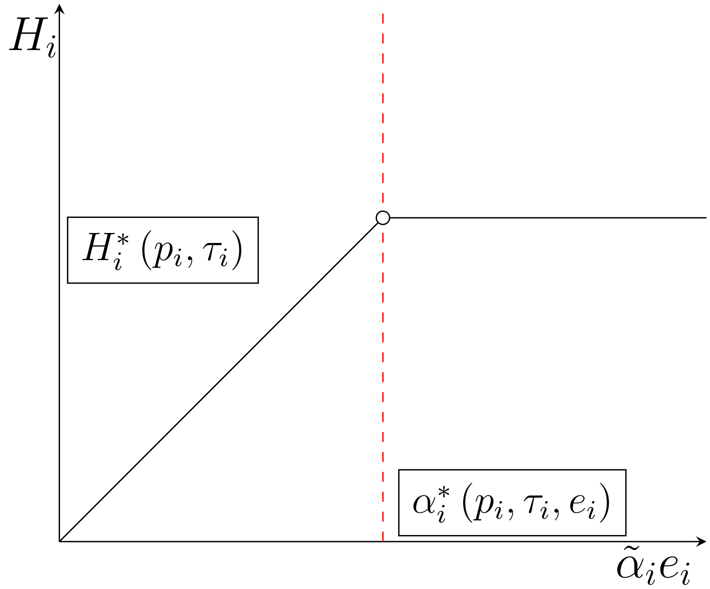
The Kuhn-Tucker conditions with respect to H_i, $i = 1, \ldots, N$ produce:

$$\forall\, \tilde{\alpha}_i,\ u'[\tau_i p_i - G_1(H_i, p_i)] + \mu_i = 0,\ i = 1, \ldots, N$$

An interior solution is therefore given by $0 < H_i < \tilde{\alpha}_i e_i$, hence $\mu_i = 0$ and: $\tau_i p_i = G_1(H_i, p_i)$. Figure A.1 shows concealed volume as a function of realized output.

[43]The fixed cost captures the costs incurred by attempting to conquer the economy (waging troops, logistics), maintaining control, and the costs of ensuring credible commitment.

Figure A.1: Labor real productivity and volume hidden by miners



Notes: This figure represents the relationship between the volume of output hidden in sector i, H_i, and the realized output in sector i, $\tilde{\alpha}_i e_i$ derived from the miner's first order conditions. If the realized labor real productivity is below a certain threshold (left side of the picture), the miner is at a corner solution and hides all output (right side of the picture). If the realized labor real productivity is above the threshold, the volume hidden is an interior solution.

Second, the miners choose labor supply and labor to conceal:

$$\begin{array}{ll}\max\limits_{e;e^H} & \int_{\tilde{\alpha}_1} ... \int_{\tilde{\alpha_N}} u \left(\sum\limits_{i=1}^{N} \left(\left(1-\tau_i\right) p_i \tilde{\alpha}_i e_i + \tau_i p_i H_i^*(p_i, \tilde{\alpha}_i, e_i, \tau_i) - t_i \tilde{e}_i - G^i(H_i^*(p_i, \tilde{\alpha}_i, e_i, \tau_i), p_i) - E^i\left(e_i^H, p_i\right)\right)\right) f(\tilde{\alpha}) \mathrm{d}\tilde{\alpha}_1 ... \mathrm{d}\tilde{\alpha_N} - c(e) \\ \text{s.t.} & e_i^H \leq e_i, \ i = 1, 2, \ldots, N \end{array}$$

An interior solution for $e_i^H$is given by $e_i^H < e_i$ and $e_i^H > 0$: $t_i = E_1(e_i^H, p_i)$. The first order conditions with respect to e_i, $i = 1, \ldots, N$ produces N additional equations:

$$\int (\mathrm{u}' \left[(1-\tau_\mathrm{i})\mathrm{p_i}\tilde{\alpha}_\mathrm{i} - \mathrm{t_i}\right] + \mu_\mathrm{i}\tilde{\alpha}_\mathrm{i}) dF(\alpha) - \lambda_i - c'(e_i) = 0, \ i = 1, \ldots, N$$

for sectors where the output hiding constraint is binding, and for sectors where it is not:

$$\int (\mathrm{u}' \left[(1-\tau_\mathrm{i})\mathrm{p_i}\tilde{\alpha}_\mathrm{i} - \mathrm{t_i}\right]) dF(\alpha) - \lambda_i - c'(e_i) = 0, \ i = 1, \ldots, N$$

The stationary bandit maximizes:

Proposition 1 recovers Ramsey (1927)'s result: the optimal tax is inversely proportional to tax elasticity. Even if gold output could be taxed, because it is easier to conceal, optimal output tax

$$
\begin{aligned}
V_s = \max_{\tau,t} \quad & E_\alpha \sum_{i=1}^{N} \left[p_i\tau_i\left(\tilde{\alpha}_i e_i^*\left(p,\tau,t\right) - H_i^*\left(p_i,\tilde{\alpha}_i e_i,\tau_i\right)\right) + t\tilde{e}_i^*\left(p,\tau,t\right)\right] \\
\text{s.t.} \quad & E_\alpha u\left(\sum_{i=1}^{N}\left(\left(1-\tau_i\right)p_i\tilde{\alpha}_i e_i^* + \tau_i p_i H_i^* - t_i\tilde{e^*}_i - G^i(H_i^*,p_i) - E^i\left(e_i^{H*},p_i\right)\right)\right) - c(e^*) \geq 0
\end{aligned}
$$

is lower in gold mines—and thus, so is the direct effect of price changes on tax revenue. Similarly, if output is sufficiently easy to hide, the optimal tax on gold output is zero.

Proposition 1. *[Ramsey taxation and elasticity of taxable output]*

Part 1—Interior output tax: *When labor tax is not available,*

$$
\frac{\tau_l^*}{1-\tau_l^*} = \frac{E_\alpha[\tilde{y}_l]}{E_\alpha\left[\tilde{y}_l \times [\tilde{\varepsilon}_l^{y_l} + \sum_{i\neq l}^{N} \frac{\tau_i^*\tilde{y}_i}{\tau_l^*\tilde{y}_l}\tilde{\varepsilon}_l^{y_i}]\right]}
$$

where: $\tilde{\varepsilon}_l^{y_i} = \frac{\frac{\partial\tilde{y}_i}{\partial(1-\tau_l)}}{\tilde{y}_i}(1-\tau_l)$ *is the elasticity of observable output in sector i to an output tax in sector l.*[44]

Part 2—Zero output tax *Let $\underline{H_i} \in R$ such that $\forall H_i < \underline{H_i}$, $G_1^i(H_i,p_i) = 0$. Let $\overline{\alpha}_i = sup\{A_i\}$, where A_i is the set of real labor productivity realizations in sector g. Assumption G1 is $\overline{\alpha_i}L \leq \underline{H_i}$. Let T_i be a fixed cost of taxing output. Assumption G2 is $\tau_i^* p_i \int\left(\tilde{\alpha}_i e_i - H_i\right) dF_i(\tilde{\alpha}_i) < T_i$.*

i) If assumption G1 holds, then $\forall\tau_i > 0$, $H_i^* = \tilde{\alpha}_i e_i$, ii) If assumption G2 holds, then $\tau_i^* = 0$.

Proof of proposition 1. Part 1 follows from Leibniz integral rule and linearity of expectation. I next provide a numerical example explaining part 2. Suppose there is only one sector, so I drop the sector identifiers i. Let $G(H,p) = k\frac{H^2}{2}$. Parameter k captures the cost of hiding output. Let $c(e) = \frac{e^2}{2}$ and the utility function be linear in consumption. Labor supply in this form is isoelastic, and the optimal tax is: $\tau^* = \frac{1}{2}\frac{1}{1+\frac{1}{\alpha^2 k}}$. The optimal tax is larger the higher is the cost to conceal an additional unit of output. At the limit, if output cannot be concealed:

$$
\lim_{k\to+\infty} \tau^* = \frac{1}{2}\frac{1}{1+\frac{1}{\alpha^2 k}} = \frac{1}{2}
$$

[44] If the bandit would instead maximize a social welfare function, such as a Bergson-Samuelson functional, the optimal taxes would lie between the revenue maximizing taxes and zero. Revenue maximizing optimal taxes can be derived from the maximization of a social welfare function when the weighted average of the social marginal utilities is zero. For a review of the optimal taxation literature, see Piketty and Saez (2012).

This is because labor supply is isoelastic and always equal to 1, which can be seen from the inverse elasticities rule. If $k \in R^{+}$, $0 < \tau^{*} < \frac{1}{2}$. When α is large τ^{*} approaches its upper bound, and when α is small, τ^{*} tends to 0. Since $\overline{\alpha}_g \approx 0$, the optimal tax in a mine where the only sector is gold will be low. Furthermore, if $\overline{\alpha}_g$ is sufficiently low so that $\overline{\alpha}_g L < \underline{H}$ (assumption G1, which could hold, for example, for function $G(H, p) = 1\{H \geq \underline{H}\} \times k\frac{(H-\underline{H})^2}{2}$ with $\underline{H} > 0$), the choice of tax is irrelevant and always raises no revenues, since output is always hidden. Turning to assumption G2, the tax revenue can be written as:

$$\begin{aligned} V_s &= \frac{1}{2}\frac{\alpha^2 p^2}{\alpha^2 + \frac{1}{k}}\left(\alpha^2(1-\tau) - \frac{\tau}{k}\right) \\ &= \frac{1}{4}\frac{\alpha^4 p^2}{\alpha^2 + \frac{1}{k}} \end{aligned}$$

which is strictly increasing in α with $\lim_{\alpha \to 0} V_s = 0$. Therefore, $\exists \underline{\alpha}$ s.t. $\forall \alpha < \underline{\alpha},\ R(\alpha) \leq T,\ \tau^{*} = 0$ and $\forall \alpha > \underline{\alpha},\ R(\alpha) > T,\ \tau^{*} > 0$

□

Proposition 2 examines the effect of a price increase on the value of becoming a stationary bandit. Proposition 3 compares such effect for mines where hiding output is costly to mines where it is not. For simplicity, I focus on two mines: one with a mineral whose output can be taxed, *ct* (for coltan), and a second, whose output cannot be taxed, *g*. Proposition 3 examines the role of trade infrastructure.

Proposition 2. *[Effect of the output price on the stationary bandit's indirect utility] Assume there are realizations of α for which the solution is interior with respect to either labor or output, G is homogeneous of degree one with respect to p, and E does not depend on p. Then,* $\frac{dE_\alpha V_s}{dp} > 0$.

Proof of proposition 2. Let $\tilde{e}_i = e_i - e_i^H$ be the observable labor input in sector i,

$$\frac{dE_\alpha V_s}{dp_{ct}} = E_\alpha(\alpha_{ct})\left[\tau_{ct}\left(e^{*}_{ct} + p_{ct}\frac{\partial e^{*}_{ct}}{\partial p_{ct}}\right)\right] - E_\alpha\left[\tau_{ct}\left(H^{*}_{ct} + p_{ct}\frac{\partial H^{*}_{ct}}{\partial p_{ct}}\right)\right] + t_{ct}\frac{\partial \tilde{e}^{*}_{ct}}{\partial p_{ct}}$$

and

$$\frac{dE_\alpha V_s}{dp_g} = \frac{\partial \tilde{e}^{*}_g}{\partial p_g} t_g$$

Consider the following example, which satisfies the homogeneity assumption of the proposition.

Let $c(e_i) = \frac{1}{2}e_i^2$, $E(e_i^H, p_i) = \frac{c}{2}\left(e_i^H\right)^2$, $G(H_i, p_i) = \frac{p_i h_i}{2}H_i^2$. Dropping the mineral identifiers, the miner's and bandit's programs are now, respectively:

$$\max_{e,e_H,H} \quad (1-\tau)\,p\alpha e + \tau p H - t\,(e - e_H) - \tfrac{1}{2}e^2 - \tfrac{c}{2}e_H^2 - \tfrac{ph}{2}H^2$$

$$\max_{t,\tau} \quad \tau p\,(\alpha e - H) + t\,(e - e_H)$$

The optimal taxes are:

$$\tau^* = \frac{1}{2}\frac{p\alpha^2 h}{p\alpha^2 h + c + 1}, t^* = \frac{1}{2}\frac{p\alpha c}{p\alpha^2 h + c + 1}$$

It follows that the value from operating as stationary bandit V_s is given by:

$$V_s = \frac{(p\alpha)^2}{4}\left[1 - \frac{1}{p\alpha^2 h + c + 1}\right]$$

Direct differentiation yields:

$$\frac{dV_s}{dp} = \frac{p\alpha^2}{2}\left[1 - \frac{1}{p\alpha^2 h + c + 1} + \frac{1}{2}\frac{p\alpha^2 h}{(p\alpha^2 h + c + 1)^2}\right] > 0$$

□

A rise in the output price in one location affects the indirect utility from being a stationary bandit in that location through three channels. First, it raises the value of each unit of output taxed (first term). Second, it increases the value of output taxed that is lost to hiding activities, and it affects the the amount of labor hidden, and thus taxable (second term). Third, it changes labor supplied by miners, and thus the units of labor taxed (third term). If a higher output price creates an income effect on miners that dominates its substitution effect towards labor supply, labor supply decreases. With generally weak assumptions about the cost of concealing output and labor, the price increases labor supply and thus total output. Furthermore, in mines where output cannot be all hidden ($i = g$), it affects the incentives to hide output. If the increase in the optimal output hidden is "not too large" a higher price increases indirect utility from being a stationary bandit.

Proposition 3. *[Heterogeneous effect of the output price on the stationary bandit's indirect utility, by cost of hiding output.] Let* $G^i(H_i, p_i) = \frac{p_i h_i}{2} H_i^2$*, where* $p_i h_i$ *is the slope of the marginal cost curve (in dollars), and so* h_i *governs the marginal cost in units of output. Let* $E^i(e_i^H, p_i) = \frac{c}{2} e_H^2$*, and* $c(e) = \frac{1}{2} e^2$*. Let* $u(x) = x$*. Assume* $\alpha_i > 0$*. The effect of a price increase on the stationary bandit's indirect utility is stronger when hiding output is costlier for the miner,* $\frac{\partial^2 V_s}{\partial p_i \partial h} > 0$*. Furthermore, consider two mines, each with one sector. Mine ct has only sector* $i = ct$*, and mine g has only sector* $i = g$*. Suppose that* $h_g = 0$*, so output of sector g is not taxed, and denote* $h_{ct} = h$*. Then:*

$$\frac{dV_s}{dp_{ct}} - \frac{dV_s}{dp_g} > 0 \Leftrightarrow F(p_{ct}, \alpha_{ct}, p_g, \alpha_g, h, c) > 0$$

F is increasing in α_{ct}, p_{ct} *and h, decreasing in* α_g *and* p_g *and decreasing in c as long as h is sufficiently high.*

Proof of proposition 3. It is straightforward to show that an increase in the cost of hiding output impacts the effect of price on the tax revenue of the bandit positively:

$$\frac{\partial^2 V_s}{\partial p_i \partial h} = \frac{1}{4} \frac{p_i^3 \alpha_i^6 h + 3 p_i^2 \alpha_i^4 (c+1)}{(p_i \alpha_i^2 h + c + 1)^3} > 0$$

Let us now allow $\alpha_g \neq \alpha_{ct}$ and $p_g \neq p_{ct}$. For gold, there is no tax on output, therefore:

$$\frac{dV_s}{dp_g} = \frac{p_g \alpha_g^2}{2} \frac{c}{1+c}$$

We then have:

$$\frac{dV_s}{dp_{ct}} - \frac{dV_s}{dp_g} = \frac{p_{ct} \alpha_{ct}^2}{2} - \frac{1}{4h} \left[1 - \left(\frac{c+1}{p_{ct} \alpha_{ct}^2 h + c + 1} \right)^2 \right] - \frac{p_g \alpha_g^2}{2} \frac{c}{1+c}$$

Differentiation shows that this expression increases in response to increases in p_{ct}, α_{ct} and h — value of stationarity at coltan mines grows relatively more in response to price shock, when the real productivity of coltan is high and hiding coltan output is costly. Similarly, the value of being a stationary bandit at gold mines responds more to the price shock if the real productivity of gold is high. If h is high enough, so that most taxation at coltan mines happens through output taxes, the value of being a stationary bandit at gold mines responds more to shocks in c than the value of being a stationary bandit at coltan mines—c determines whether labor taxation is efficient. □

Parameterizing α_g, α_{ct}, p_g, p_{ct} with the values of 1999, we have $\alpha_g = .5g$, $\alpha_{ct} = 10,000g$, $p_g = 10\ USD.g^-1$, $p_{ct} = .05USD.g^-1$. With this values, any reasonable values of for c and h imply that a unitary rise in the price of coltan had a larger effect on stationary bandit revenues than a unitary price in the price of gold. Figure A.2 plots the value of $D = \frac{dV_s}{dp_{ct}} - \frac{dV_s}{dp_g}$ for different values of h and c. As shown in proposition 3, $\frac{dV_s}{dp_{ct}} - \frac{dV_s}{dp_g}$ decreases in c and increases in h. Furthermore, for $D > 0$, it is necessary that labor is not excessively costly to hide—otherwise for given α_g, α_{ct}, p_g, p_{ct}, it is possible to capture the increase in added value stemming from the price increase simply through a labor tax, which is possible in gold. Allowing the cost of hiding labor to be smaller in gold, consistent with empirical observation that gold labor is harder to tax because it often occurs alongside rivers, only reinforces the result that $D > 0$.

When output is stochastic, this result is strengthened. In that case, the optimal tax is a risk sharing contract. Therefore, removing the option to tax output generates an efficiency loss through an additional channel, stemming from the fact that the bandit has less tax instruments to absorb risk from risk averse miners.

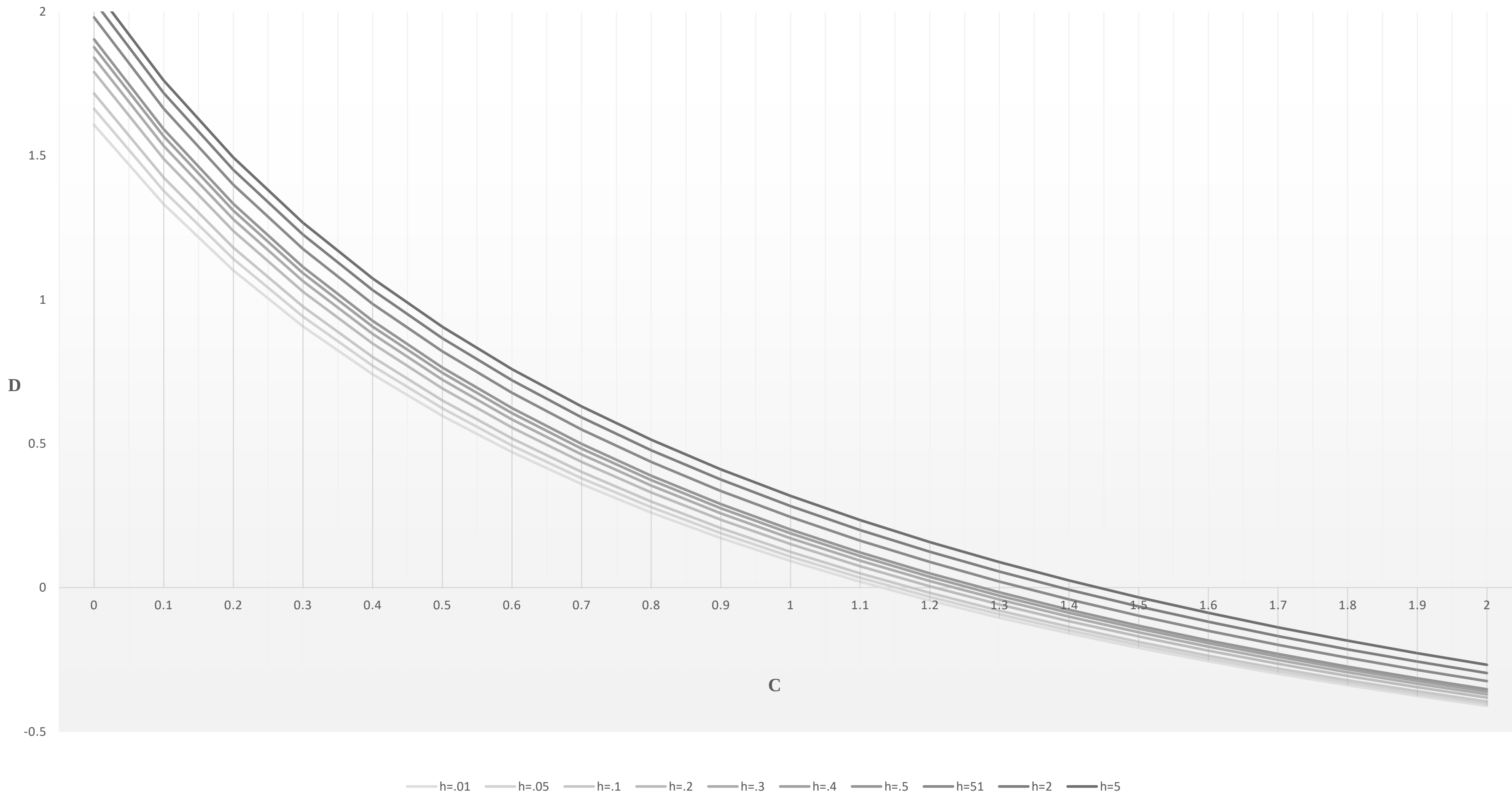
Proposition 4. *[Heterogeneous effect of the output price on the stationary bandit's indirect utility, by accessibility of trade infrastructure.] The assumptions of Proposition 3 apply. For mines that are far from their respective trade infrastructure (for instance, airports for coltan), fluctuations in global demand have no effect on the indirect utility of a stationary bandit.*

Proof. Where trade costs for coltan are arbitrarily high, $p = 0$. In that case:

$$\frac{dV_s}{dp} = \frac{p\alpha^2}{2}\left[1 - \frac{1}{p\alpha^2 h + c + 1} + \frac{1}{2}\frac{p\alpha^2 h}{(p\alpha^2 h + c + 1)^2}\right] = 0$$

Thus, let V_s^{TC} be V_S for mines where there are no airports. Assume that road transport costs are so high that in the absence of an airport, there is no market for coltan. Thus $\frac{dV_s}{dp} - \frac{dV_s^{TC}}{dp} > 0$. □

Figure A.2: Parameterized $D = \frac{dV_s}{dp_{ct}} - \frac{dV_s}{dp_g}$ using empirically observed values of α_g, α_{ct}, p_g, p_{ct}



Notes: This figure plots the parameterized value of $D = \frac{dV_s}{dp_{ct}} - \frac{dV_s}{dp_g}$ using empirically observed values of $\alpha_g = .5g$, $\alpha_{ct} = 10,000g$, $p_g = 10USD.g^-1$, $p_{ct} = .05USD.g^-1$ observed in 1999 for different values of h and c.

A.1.2 Extension 1: stationary bandit's endogenous ability to commit to a tax rate

In Section A.1.1, it is assumed that if the stationary bandit holds a monopoly of violence, he can offer a credible taxation plan with perfect commitment. The cost of acquiring this credibility may included in F, which could capture, for instance, a costly signal of the value of the relationship or power concessions that limit the stationary bandit's ability to arbitrarily expropriate after workers produce. Here, I endogenize the incentive of the stationary bandit to commit to his taxation plan, in order to provide conditions under which a taxation plan is sustainable, instead of breakdown.

If the interaction between the stationary bandit and the miners was not repeated, absent social preferences, honoring the taxation plan cannot not be an equilibrium unless it is assumed: the bandit would be tempted to fully expropriate and the miners would anticipate his pillage and would not produce.[45] Unable to sign formal contracts enforced by an independent third-party, bandits can use the value of the future to provide assurance to the population that they will respect the taxation plan.[46]

Suppose an armed actor has been successful at establishing a monopoly of violence in the mine. Assume the mine has one sector, with nominal output $y = pY$ and with output tax τ. Let τ^* be the feasible tax that would maximize the stationary bandit's static tax revenue, if it was credible. If the bandit honors his taxation plan, $T = 1$, and he obtains $\tau^* y$. If the bandit reneges (he pillages), $T = 0$, and he obtains y. The miners can either work, $W = 1$, or migrate, $W = 0$. If they work, and the stationary bandit honors his promise, they obtain $(1 - \tau^*)y$, while they obtain 0 if he does not. If they migrate, they obtain m, where $m > 0$. If the bandit reneges and the miners migrate, the bandit obtains $V_R \in R^+$ (roving value), where $V_R > 0$. Propositions 5 and 6 establish the conditions under which a taxation equilibrium exists. Let S denote the number of periods and $\beta \in \{0; 1\}$ the time preferences parameter.

Proposition 5. *If $S = 1$, the unique Nash equilibrium in pure strategies is $\{T, W\} = \{0, 0\}$*

Proof of proposition 5. This follows from applying the bandit and miners' best responses. □

[45] I motivate the modeling choice with interviews with armed actors. A first conversation reveals that taxation hinges on a relationship between the bandit and the population: *"To pillage is a sign that we are not going to live in the mine. To settle in the mine implies that we have to create relations at the mine to deserve the trust of the population."* A second conversation emphasizes the role future interactions to discipline the bandit: *"When we know we will leave the mine, we try to steal as much as possible. This is why the armed man is never a friend if he finds no interest in it."*

[46] If there was a state, the stationary bandit would be illegal, but since there is no state, the stationary bandit is the one creating and enforcing the law, hence lacks a credible commitment device.

Proposition 6. *$S = +\infty$ and per period probability of termination is $1 - \pi_s$. A taxation Nash equilibrium exists, where the bandit plays $T = 1$ if the miner never migrated, and $T = 0$ otherwise, and the miner plays $W = 1$ if the bandit never pillaged and $W = 0$ otherwise if and only if:*

$$\frac{\beta \pi_s V_R}{y} + 1 - \tilde{\pi}_s < \tau < 1 - \frac{m}{y}$$

A necessary condition is $y \geq \bar{y} = V_R + \frac{m}{\beta \pi_s}$.

Proof of proposition 6. The results follows directly from applying the bandit and miners' best responses in the infinitely repeated game. □

Thus, taxation is more likely to be sustained the larger is real output Y, the larger is the price of output p, the smaller is the probability of termination $1 - \pi_s$, the larger is the time preferences parameter β, the smaller is the outside option of the stationary bandit, V_R, and the smaller is the outside option of the population, m—thus, the larger is the surplus of the relationship of taxation. If $y \geq \bar{y} = V_R + \frac{m}{\tilde{\pi}_s}$, then there exists a range of feasible tax rates that sustain the taxation relational contract. In what follows, I assume that the joint surplus is sufficiently large to sustain taxation, whenever a bandit acquires the stationary bandit.

Proposition 7 provides sufficient conditions for the effect of a rise in the output price on the likelihood of taxation. A mine is endowed with one sector, output is non-stochastic, and only one bandit can establish a monopoly of violence.

Proposition 7. *[Effect of the output price on the breakdown of the taxation equilibrium] Let ϵ_p^y be the semi-elasticity of income with respect to price. If $-\frac{\tilde{\pi}_s V_R}{y} \epsilon_p^y < \frac{\partial \tau^*}{\partial p} < \frac{m}{y} \epsilon_p^y$, a rise in the output price p increases the range of parameters consistent with a taxation contract. A sufficient condition for $-\frac{\tilde{\pi}_s V_R}{y} \epsilon_p^y < \frac{\partial \tau^*}{\partial p} < \frac{m}{y} \epsilon_p^y$ is that labor supply is isoelastic, in which case $\frac{\partial \tau^*}{\partial p} = 0$.*

Proof of proposition 7. From $\frac{\tilde{\pi}_s V_R}{y} + 1 - \tilde{\pi}_s < \tau^* < 1 - \frac{m}{y}$, the left hand side is decreasing in p and the right hand side is increasing in p. □

A.1.3 Extension 2: endogenous contestation for the monopoly of violence

This section allows multiple armed actors to contest the monopoly of violence. An armed actor can choose to establish a monopoly of violence at cost F in the mine, $s_b = 1$, or instead be roving,

$s_b = 0$. If the bandit acquires the monopoly of violence, he can design a taxation contract, so long as the tax that he proposes can be sustained as a self-enforcing equilibrium. Let $\pi_s(s_b; s_{-b}) \in [0;1]$ be a contest success function for property over the monopoly of violence, such that for bandit b $\pi_s(s_b, s_{-b}) \in [0,1]$ is defined as long as $s_b + s_{-b} > 0$ with $\pi_s(1;0) = 1, \pi_s(0;1) = 0, \pi_s(1;1) = \pi_s$. The two armed actors are heterogeneous. If the monopolist of violence is overthrown, his payoffs terminate. I focus on cases where taxation contracts can be sustained.

Proposition 8 accounts for the effect on contestation when multilple armed actors can compete over the monopoly of violence (endogenous contestation).

Proposition 8. *[Effect of the output price on the benefit of establishing a monopoly of violence with endogenous contestation] Multiple bandits to compete over the monopoly of violence,* $\pi_s(s_b; s_{-b}) \in \{0; \pi\}$. $\exists\, p^S, p^W \in R,\ p^S < p^W$ *s.t.* $\forall p < p^S$ $\{s_b = 0; s_{-b} = 0\}$ *is the unique Nash Equilibrium in pure strategies;* $\forall p^S < p < p^W$ $\{s_b = 1; s_{-b} = 0\}$ *and* $\{s_b = 0; s_{-b} = 1\}$ *are the two Nash equilibria in pure strategies;* $\forall p > p^W$ $\{s_b = 1; s_{-b} = 1\}$ *is the unique Nash Equilibrium in pure strategies.*

An increase in the output price for the mineral that is produced in the mine economy increases the returns to form a monopoly of violence. While the possibility of contestation reduces such effect, the effect is stronger for bandits with a better technology of violence and higher π_s.

A.1.4 Extension 3: Endogenous value of being a roving bandit

Changes in the output price may also change the value of remaining roving bandit through the value of what roving bandits can expropriate and the labor supply and hiding choices of miners. In what follows, I examine the conditions under which an armed actor, who could instead remain roving, will prefer to become stationary bandit.

Roving bandits cannot tax labor. However, roving bandits expropriate all of the output that has not been hidden. Let q be equal to the probability with which miners expect a roving bandit to expropriate them. Such expectation is mutually consistent, for instance, if there is one roving bandit in the mine and the bandit expropriates each period a share q of miners (this can be, for instance, the maximum he can target). Conversely, this can also be mutually consistent if roving bandits expropriate the entire mine if they target the mine, but there are more mines than roving bandits and each mine that does not have a stationary bandit is targeted by a roving bandit with probability q. Let V_s be per-period value of operating as stationary bandit, V_r be per-period value of roving. Given the same functional forms as in proposition Proposition 3, Proposition 9 provides conditions for when an increase in the price disproportionately increase the value of becoming stationary bandit (assuming this leads to a feasible credible tax plan with commitment and with no contesting armed actors). The proposition focuses on mines with one sector, where labor cannot be taxed (for simplicity) and where output can be taxed—it thus aims to provide conditions for when a shock to the price of coltan disproportionately leads armed actors to become stationary bandits in coltan rather than leading them to prefer coltan mines.

Proposition 9. *[Stationary vs. roving bandit] Consider the same functional form assumptions as in proposition Proposition 3. Labor cannot be taxed and output can be taxed.*

- *If $\frac{1}{h} \geq (1-q)p\alpha^2$, so that hiding technology is relatively costless at the margin, then roving brings zero return and then $\frac{\partial V_s}{\partial p} - \frac{\partial V_r}{\partial p} > 0$ is implied by $\frac{\partial V_s}{\partial p} > 0$*
- *If $\frac{1}{h} < (1-q)p\alpha^2$, so that hiding is relatively costly at the margin $\frac{\partial V_s}{\partial p} > 0, \frac{\partial V_r}{\partial p} > 0$. There exists $\hat{q} \in [0, \bar{q} < 1]$ such that:*

$$\forall q < \hat{q}, \frac{dV_s}{dp} - \frac{\partial V_r}{\partial p} < 0$$

$$\forall q > \hat{q}, \frac{\partial V_s}{\partial p} - \frac{\partial V_r}{\partial p} > 0$$

$\hat{q}$ is increasing in the parameter that governs the marginal cost of hiding, h, the price of output p, as well as the productivity parameter α.

Proposition 9 provides conditions so that the effect of the price is stronger on the indirect utility of becoming a stationary bandit than the indirect utility of being roving. If the cost of hiding output is sufficiently small, $\frac{dV_s}{dp} - \frac{\partial V_r}{\partial p} < 0$ always holds. If the cost of hiding output is large, however, then the result depends on the underlying presence of roving bandits. Then, there are two cases. Case 1: the environment is secure (low q), then the distortion on labor supply is small, and roving bandits act as residual claimants on output. As a result, in this case, roving bandits are more responsive to price shocks than stationary bandits—who, instead, expropriate output at rate $\tau^* < 1$. Case 2: the environment is insecure (high $\hat{q}$), distortions in labor supply induced by the anticipated expropriation of roving bandits are more important, and this dampens the increase in indirect utility from remaining roving stemming from the price increase. This distinction comes from the distortions that q and the cost of hiding output generate on the labor supplied by workers who anticipate weak property rights and hard to hide output. I assume that the environment in Eastern Congo is sufficiently insecure, so that $q > \hat{q}(h)$.

A limitation is that I ignore the interactions between these extensions. For instance, a rise in contestation, by increasing the probability of termination, might make it harder for any stationary bandit to maintain a credible taxation plan, and can lead to collapse of the stationary bandit equilibrium, leading the stationary bandit to expropriate all of the unhidden surplus, and the miners to anticipate that. In this paper, it is enough to assume that, because of sorting of the strongest armed actors into stationary bandits, contestation has a minimal effect on the ability of stationary bandits to maintain a credible taxation plan.

A.2 Stationary bandits and taxation in a consumption economy

In a village economy, in contrast to a mine economy, there is no production. Instead, households (which, empirically are the families of the miners who work at the mines and the miners themselves), are endowed with wealth derived from the mining sector, and save their wealth in assets with different returns. When stationary bandits govern the village, they hence do not tax production, and instead tax family income directly. However, families try hard to evade taxation, which generates a new problem to the village stationary bandit. To characterize behavior in a village economy, I use a framework and notation close to Besley and Persson (2009).

Population and timing

The village is composed of two groups: members of the stationary bandit elite ($G = B$ for bandit), and the rest of the population ($G = P$ for population). In what follows, I refer interchangeably to members of the stationary bandit elite as "stationary bandits," even if there is only one stationary bandit organization in the village (one monopoly of violence), since such organization can be composed of $n \geq 1$ individuals. When a stationary bandit group has chosen to take power, the stationary bandit elite always governs the monopoly of violence, and the population never does. This assumption illustrates the autocratic nature of states-in-the-making, where the asymmetry of power is sufficiently large (stationary bandits have the guns), there are no elections, and the likelihood of overthrow is zero - if there is a rebellion, which is very unlikely, the stationary bandit simply leaves the village, and thus many of the dynamic considerations of state capacity are not at play. Each group composes respectively the shares β^B and β^P of the entire village "population."

There are two periods, $s = 1, 2$.

Investment and savings

Each villager is endowed with initial wealth. Villagers of the stationary bandit elite are endowed with w_B and villages from the population are endowed with w_P. The main economic activity in the village is consumption and investment of wealth into projects that yield a given return. For instance, think of investments that improve agricultural land, or investments into small shops. This type of investment also includes a marriage, since marrying is costly (bride price) and yields a return over time (labor services of the bride, labor value of the progeniture, and even protection of property rights by the progeniture). A fraction σ^G of households in each group has access to projects with return r^H, while the rest of the group has access to projects with return r^L, where $r_H > r_L$. Borrowing to invest in these projects occurs in a competitive capital market, there is thus one market interest rate every period which clears the market, r_s.

In order to borrow, however, households need to put some collateral. For instance, a household of group G who wants to get married and obtains credit from other villages in order to afford the bride price will need to write down a contract that specifies that he will make available collateral $c \leq w^G$ in case he does not return the funds. However, as is straightforward to imagine, such contracts may be violated, and the household may be able to keep a share of the collateral ex-post. This imperfect protection of the creditor's right is represented by the share, p_s^G, which captures the share of the collateral that the creditor will obtain in case of default, but also the probability of defection. Hence, a better enforcement of property rights is associated with a higher $p_s^G, \forall G$. The level of property rights protection is limited by an implementation capacity constraint by the stationary bandit who governs the monopoly of violence: $p_s^G \in [0, P_s]$, with $P_S \leq 1$. Such capacity captures the legal capacity of the stationary bandit: if the stationary bandit has invested, for instance, in tribunals and dispute resolution mechanisms that are credible, and that gather sufficient information through monitoring, he will operate with a higher level of P_s. It would be natural to assume that $\sigma^B = 0$ and $\sigma^P = \sigma \leq 1$. Stationary bandits have high liquidity from taxation, but have no productive activities. Such assumption would explain, for instance, why certain stationary bandits act as bankers for the population, or extract resources by creating forced debt. In what follows, I operate without this assumption but discuss when it plays a role. I assume that in the absence of a stationary bandit, enforcement of contracts does not attain the legal capacity, $p_s^G < P_1$. Assuming enforcement to be zero would be ignoring the traditional system of justice that exists independently of any stationary bandit, but certainly, such traditional system of justice hinges on informal mechanisms of contract enforcement, and is thus less efficient than the one that can be achieved by a stationary bandit who has guns and can coerce debtors into paying a collateral by force. Another way to assume this is simply to note that legal capacity in the absence of a stationary bandit is lower than with a stationary bandit, i.e. $P^T < P_1$, and constant - it does not need to be constant, but it is simpler for exposition.

Given this, I can characterize the capital market equilibrium. It is straightforward to see that if all individuals invest a fixed share of their wealth l_s, the capital market equilibrium is pinned down by the following equality:

$$\sigma^B \beta^B p_s^B w^B + \sigma^P \beta^P p_s^P w^P = l_s[(1-\sigma^B)\beta^G w^B + (1-\sigma^P)\beta^P w^P] \tag{3}$$

The first term is the demand for credit. Clearly, high return individuals invest all of their wealth, demand up to $\sigma^G \beta^G p_s^G w^G$ in credit, and low return individuals lend all their wealth up to l_s. Competitive markets imply that price equals to marginal cost, hence $r_s = r_L$.

State in the making: taxation, security, enforcement

Stationary bandits can tax income (although they do not observe the specific projects), and can choose the level of property rights protection. In addition, they choose the level of public goods, which are assumed to benefit stationary bandits and the population equally — think, for instance, of security services (protection) against outside roving bandits, which affects both groups equally.

The stationary bandit can tax at time s the income of group G, and thus chooses t_s^G. However, when facing a tax, a household can go informal. If the household goes informal, the friction of hiding the income implies a decrease in the return to investment, so that a household who goes informal earns $(1 - T_s)$ of the normal returns. This means that the stationary bandit can only tax up to T_s, in each period s, beyond which point the group whose income tax is higher than T_s goes informal altogether. This taxation capacity constraint captures the ability of the stationary bandit to tax, in other terms, fiscal capacity.

To improve fiscal capacity, the stationary bandit can invest, at a cost, in making it costlier to households to evade taxes in period two, thus increasing T_2. They can make it costlier to households by improving their own ability to monitor households' tax evasion (and thus the expected cost of evading taxes). They can also deter tax evasion by increasing the sanction if households get caught, in which case this is unlikely to require investment. I thus consider investments in this "fiscal capacity" as the creation of a tax administration by the stationary bandit, aimed at monitoring transactions and increasing the probability that households get caught. By having a better fiscal capacity, thus, T_s is larger, which increases the maximum tax rate that stationary bandits can choose and still extract taxes. Investing in fiscal capacity for the future is costly. It costs $F_s(T_2 - T_1)$ to the stationary bandit to increase fiscal capacity by $T_2 - T_1$ — assume that the constraint $T_2 \geq T_1$ holds, i.e. fiscal capacity can only increase. Furthermore, assume that fiscal capacity does not depreciate. $F_s(.)$ is monotonically increasing and convex, and $F_2(.) = 0$.

Similarly, the stationary bandit can choose the level of creditor property rights protection, p_s^G, up to the maximum that he can enforce, P_s. However, the stationary bandit in period 1 can invest in the capacity to enforce contracts in period 2, P_2, although such investment is costly. In particular, to increase the contract enforcement capacity from P_1 to P_2, it costs the stationary bandit $L_s(P_2 - P_1)$. Similarly, contract enforcement capacity does not depreciate, and $P_2 \geq P_1$. $L_s(.)$ is monotonically increasing and convex, and $L_2(.) = 0$. I refer to the ability to enforce dispute resolution, and the capacity to enforce contracts as legal capacity.

The stationary bandit can select the level of security provision at time s, S_s, where S_s stands for safety. Security provision is a service that both groups of villagers (members of the stationary bandit elite and the rest of the population) value equally, by a factor of a. The value of providing security is higher, the higher is the counterfactual level of security - the higher the threat of pillages by roving bandits who expropriate the assets of both groups of villagers equally. Clearly, if in the absence of the stationary bandit, there is no threat of expropriation, the value of security provision is zero, i.e. $a_s = 0$. Thus, the utility value of the public good to any villager is aS_s.

Finally, the stationary bandit in the village may or may not value the welfare of the population as much as his own. To simplify exposition, assume that the stationary bandit maximizes $aS_s + \Phi_B(1 - t_s^B)Y_s^B + \Phi_P(1 - t_s^P)Y_s^P$, where $\Phi_G, G \in \{B, P\}$ is the weight that the stationary bandit assigns to each population group in his objective function. Naturally $\Phi_B > \Phi_P$, although stationary bandit organizations differ in $\Phi_B - \Phi_P$: stationary bandits that arise from foreign populations and armed groups that are external to the village have a $\Phi_B - \Phi_P$ closer to one, and stationary bandit organizations that emerge as regional militia or from the village itself will have $\Phi_B - \Phi_P$ closer to zero. Let $\rho^B = \frac{\Phi_B}{\beta^B}$ and $\rho^P = \frac{\Phi_P}{\beta^P}$.

The stationary bandit's policy choice

The stationary bandit thus chooses $t_s^B, t_S^P, p_s^B, p_s^P, S_s$ to maximize:

$$aS_s + \rho^B(1 - t_s^B)\beta_B Y_s^B + \rho^P(1 - t_s^P)\beta_P Y_s^P \tag{4}$$

subject to:

$$t_s^B \beta^B Y_s^B + t_s^P \beta^P Y_s^P = G_s + L_s(P_2 - P_1) + F_s(L_2 - L_1), s \in \{1, 2\}$$

$$p_s^G \leq P_s, s \in \{1, 2\}$$

$$t_s^G \leq T_s, s \in \{1, 2\}$$

where Y_s^G indicates the output (income) by group G in period s. Since the households with high return projects invest all their wealth and obtain in addition $p_s^G w^G$ in borrowing, and have to repay at interest rate r_L, and since households with low return make r_L on their borrowed and borrowed wealth, $Y_s^G = w^G[\sigma^G(1 + p_s^G)(r_H - r_L) + r_L]$.

The state-in-the-making as contract enforcement

From the stationary bandit's problem, it is straightforward to see that since increasing p_s^G relaxes the budget constraint of the stationary bandit (through Y_s^G) and the objective function is increasing in p_s^G, the optimal level of property rights protection is the maximum allowed by the institutional constraint $p_s^G \leq P_s$, thus $p_s^G = P_s$. This is the logic of Olson (1993)'s stationary bandit: precisely because he is residual claimant through the lens of taxation, he internalizes the effect of improving economic activity.

The state-in-the-making as protection

Furthermore, when the value of safety is high (i.e., insecurity is high), $a > \overline{\rho}$, safety is provided in both periods. In such case, to finance the provision of public goods, the stationary bandit chooses the maximum level of taxes that he can collect from both groups, given the constraint to invest an exogenously given level of state capacity in period 1, i.e.: $t_s^G = T_s$, $S_2 = T_2 Y_2$, and $S_1 = T_1 Y_1 - L(P_2 - P_1) - F(T_2 - T_1)$.

The state-in-the-making as redistribution

Finally, when the value of safety is low (i.e., insecurity is low), $a < \overline{\rho}$, $S_s = 0$, all of the tax extraction occurs in order to redistribute as much as possible to the stationary bandit as long as $\Phi_B > \Phi_P$. In that case the population is taxed at full capacity in period 2, $t_2^P = T_2$ and all the tax revenues are used for the stationary bandit's consumption: $t_2^B = -\frac{T_2 \beta^P Y^P}{\beta^B Y^B}$. Identically for period one, except that the taxes collected also have to be used to finance the investments in state capacity, then $t_1^P = T_1$ and $t_1^B = \frac{L(P_2-P_1)+F(T_2-T_1)-T_1\beta^P Y^K}{\beta^B Y^B}$. To see why all the above results hold, simply totally differentiate the objective function of the stationary bandit and the budget constraint. Increasing the tax rate of group G to finance public goods changes the objective function in $(a-\rho^G)\beta^G Y^G dt_s$. Clearly, it is optimal to tax as much as possible to finance public goods whenever $a > \rho^G$, and to spend zero resources on public goods when $a < \rho^G$ but nonetheless tax the population as much as possible as long as $\Phi_B > \Phi_P$.

Proposition 10. *Extensive margin. The larger the amount of wealth in circulation in the village economy (i.e., the larger $w^B + w^P$, σ^P, σ^B), the higher the value for a bandit to take over the monopoly of violence in the village.*

It is straightforward to see how this results from the stationary bandit's objective function in the village economy: higher wealth naturally translates into higher payoff for the members of the stationary bandit group.

The stationary bandit's intensive margin: investments in fiscal and legal capacity

Let us now allow the stationary bandit to manipulate the period 2 levels of fiscal and legal capacity, T_2, P_2. The stationary bandit chooses T_2 and P_2 to maximize the period payoff, subject to the budget constraint and accounting for the payoff losses in period 1 to invest in period 2 capacity. The stationary bandit thus takes as given the static solutions and chooses T_2, P_2 to maximize:

$$a_2 G_2 + (1-t_2^B)\rho^B\beta^B Y_2^B + (1-t_2^P)\rho^P\beta^P Y_2^P - \lambda(L(P_2-P_1) - F(T_2-T_1)) \tag{5}$$

where λ is the marginal cost of not consuming public funds in period 1. Suppose $a_1 > \rho^B$ and $a_2 > \rho^B$. Then the first order conditions are:

- For legal capacity: $(r_H - r_L)\left[[\rho^B\omega^B + \rho^P\omega^P]W + T_2[(a_2-\rho^B)\omega^B + (a_2-\rho^P)\omega^P]W\right] \le \lambda L_P$ and $P_2 - P_1 \ge 0$
- For fiscal capacity: $(a_2-\rho^B)[(1+P_2)(r_H-r_L)\omega^B W + r_L\beta^B w^B] + (a_2-\rho^P)[(1+P_2)(r_H - r_L)\omega^P W + r_L\beta^P w^P] \le \lambda F_T$ and $T_2 - T_1 \ge 0$

where $\omega^G = \frac{\sigma^G w^G \beta^G}{W}$ and $W = \sigma^B w^B \beta^B + \sigma^P w^P \beta^P$ indicates the size of the local economy.

Proposition 11. *Intensive margin.*

- *The larger the amount of income in circulation in the village economy (i.e., the larger W, σ^G, or $w^B + w^P$), the larger the optimal level of fiscal and legal capacity, T_2 and P_2.*
- *The larger the productivity of local projects (i.e., the larger r^H), the larger the optimal level of fiscal and legal capacity, T_2 and P_2.*
- *Fiscal and legal capacity are complements (they thus are positively correlated in the data)*
- *The higher the initial level of fiscal and legal capacity T_1 and P_1, the higher the level of investment in state capacity $T_2 - T_1$ and $P_2 - P_1$, and therefore by construction the higher the level of state capacity in period 2.*

This proposition summarizes the intensive margin result of this paper, which is concentrated in the village economy, where fiscal and legal capacity investments are relevant.

Proposition 12. *Resource curse.*
If disinvestment in state capacity is allowed (and the constraints $T_2 - T_1 \geq 0$ and $P_2 - P_1 \geq 0$ are relaxed), negative investment may occur if the stationary bandit can migrate such capacity to tax and provide enforcement in a separate location. If a stationary bandit can also control a mine in period 2, the higher the value of output at the mine that he can tax using the state capacity resources he has invested, the higher the likelihood to observe disinvestment in state capacity at the village.

The proof follows the same logic as Proposition 11.

Proposition 13. *Welfare. This proposition has three parts:*

- *Whether the stationary bandit is composed from a population from outside the region or not, i.e. whether $\Phi_B > \Phi_P$ or $\Phi_B = \Phi_P$, if the value of public goods is sufficiently high (for instance, when there is a lot of exposure to pillages by roving bandits), the presence of a stationary bandit improves the welfare of the population.*
- *When the value of public goods is low (insecurity levels in the absence of the stationary bandit are low), the population is unambiguously better off with a regional militia (i.e. $\Phi_B = \Phi_P$), than with a stationary bandit whose members arise from outside the region (i.e. $\Phi_B > \Phi_P$).*

- *When the value of public goods is low (insecurity levels in the absence of the stationary bandit are low), the population is unambiguously better off with an external stationary bandit than without any stationary bandit at all if and only if* $T_1 < \sigma^P \frac{r_H - r_L}{r_H} \frac{P_1 - P_T}{P_1}$. *This is more likely to be true whenever the taxation capacity of the stationary bandit* (T_1) *is low, the share of productive projects* (σ^P) *is large, the return on good investments* (r_H) *is high, the return on low investments* (r_L) *is low, the traditional contract enforcement capacity* (P_T) *is low, and the stationary bandit initial legal capacity* (P_1) *is high. Furthermore, in that case, the population is unambiguously better off with a stationary bandit whose members arise from the population than with no stationary bandit at all.*

To see this, simply note that the welfare of the population is: $a_s S_s + (1 - t_s^P) w^P [\sigma^P (1 + p_s^P)(r_H - r_L) + r_L]$. Since there are no labor supply/leisure distortions, the results are straightforward plugging the corresponding values for taxation and provision of security. Furthermore, note that the condition provided in the third part of Proposition 13 contains the intuitive result that the larger the welfare losses from weak enforcement of contracts in the absence of a monopoly of violence to enforce them, the more likely it is that, even external stationary bandits, who do not care about the welfare of the population will end up increasing its welfare. A similar reasoning underpins the first part of the proposition.

B Variable definition and variable construction

This section describes the main variables that I use in this paper.

B.1 Variable definition

The goal of the data collection exercise is to collect information about the history of armed groups in each municipality. Visiting each mining site is logistically challenging, because at the time of the data collection, mines were not safe for data collectors and traveling to them was prohibitively expensive—due to high demand for transport by miners and low supply due to insecurity. I thus gathered data about the support village and its mining sites from data collection activities inside the support village, for a total o 239 support villages in Sud and Nord Kivu. This was straightforward to implement: most of the population at the support village is linked to the mine (households and traders frequently visit the mine). This design tracks the information about a location (the people), not the location. The pilot showed that this would produce reliable data. I designed separate survey modules for the support village, and for the mining sites of each municipality, all of which had to be covered separately by the data gathering. While the modules are almost identical for support villages and mines, they are adapted to the structure of support villages and mines. For instance, I do not collect output taxes for the support village.

The Sud Kivu data collection activities (henceforth, wave 1) took place in 133 municipalities between 2012 and 2013. Accounting for mining sites, wave 1 contains yearly data for 380 locations (support villages and mining sites together). The strategy in wave 2, collected in 106 municipalities in Nord Kivu in 2015 is identical to wave 1. Accounting for mining sites, wave 2 contains yearly data for 270 locations. The sample combined is a yearly dataset of 650 locations (support villages+mines) for periods ranging from 17 years to 23 years, depending on the variable and region.

The sample is a collection of municipalities, each of which contains support villages and mining sites. There are also pure agricultural municipalities, with no mining sites (excluding them or not does not change any of the results). Finally, among the municipalities that have mining sites, some mining sites are coltan, others are gold, and there are also, to a smaller extent, mining sites with other valuable resources (cassiterite/tin, tourmaline, wolfram, coffee, beans, cacao). Whenever a municipality has a production site that is valuable and produces for the market, I refer to it as mine and surveyors have to complete the mining site module for that productive site. I next describe sequentially the main variables of this paper.

Mineral endowments and prices. I capture whether a given mining site is endowed with a mineral using a dummy that is constant through the period for which I have data. This can bias my estimates downwards if the mineral had not been discovered for some years—best interpreted as an Intention To Treat (ITT) estimate. While it is conservative, it allows me nonetheless to circumvent the fact that mining output is endogenous to prices.[47] To measure prices in global markets, I use yearly US prices of minerals reported from United States Geological Survey (2016). Figure 1 shows the US prices of gold and coltan.

Stationary bandit. I define a stationary bandit as an armed actor who holds the monopoly of vi-

[47] To support this approach, I verified the dates at which minerals were discovered in each site, and dates at which they were exhausted. I do not record exhaustion of minerals in the sample, and in only one mining site, the coltan was discovered during the period under study—all the remaining deposits were known since they had been already opened by the state owned mining corporations, SOMINKI, before their collapse in 1995.

olence in a given location for a stable period of influence—usually for at least 6 months. Surveyors applied this definition while collecting the data. While surveyors also included stationary bandits of shorter duration as long as they intended to stay while they were stationary, I do not observe the number of months of each stationary bandit, since all observations are year level—because it was revealed during the study design that respondents would struggle with identifying months and also due to space constraints in the survey. Stationary bandits, which surveyors and villagers refer to as "organization of security," are a very common phenomenon in Eastern Congo. Reflecting this, the local parlance fits Olson (1993)'s definition of a stationary bandit.[48] Villagers themselves distinguished a bandit that was stationary from bandits that were roving—armed actors who have a very short term horizon (most often a few hours long), and whose objective is to expropriate output and assets as fast as possible, even if they may be stationary and peaceful with other populations or villages. Collusion between stationary bandits is easy to detect and each attack is well documented. For instance, it is known that Mayi-Mayi groups and the FDLR often conducted joint operations during the Second Congo War, and after, and sometimes held a joint monopoly of violence in the villages. The data confirm this, since there are instances of Mayi-Mayi groups jointly controlling villages with the FDLR. The data separate between episodes, even if they took place the same year. For some episodes, when there is collusion, the surveyors indicate "Mayi-Mayi and FDLR." I do not use collusion, which is only observed in very few cases. In all analysis, I exclude the state civilian authorities as stationary bandits. These include the secret service (ANR), village chiefs, chefferie chiefs, and territory administrators, and, besides village chiefs, account for an insignificant number of cases of individuals who control and tax these locations in the study.

Taxation and security services. To measure taxes, I collected information on whether a tax was levied on a given activity and at what rate. There was always consensus on whether a given expropriation was taxation or instead pillage.[49] Taxation always implied an implicit contract between the bandit and the population, so that the population knew what rate to expect, and the bandit's commitment to such rate was credible. Such contract, especially when taxes are collected at the mining site, is often accompanied with the expectation of security services by the bandit. To cap-

[48] They were commonly referred to as "organisation de securité" (security organization) in the data collection, and villagers immediately associated it with our notion of stationary bandit, even if they did not always provide security, and even if they themselves sometimes create insecurity.

[49] Local populations are familiar with distinct types of expropriation by various actors. The data suggests that at the coltan spike, the ad valorem tax rate on output was on average 1% of the value of output on each miner, and the daily tax on labor was 2% of the expected value of output produced by the miner in one day.

ture this separately from taxation, I also gathered information for each of such stationary bandits whether and when they provided security services in the location in which they were stationary. Security services often imply one or multiple organized armed actors patrolling the location during the day and night, equipped with their corresponding weapons. The question for security service at the mine was asked in two separate modules aimed to capture the same information (and thus to reduce measurement error). The wordings used were: "Did the organization provide a security service? If so let's discuss the years" and also, for each year, "Who and in what degree ensured security at the mine?"

Administration and stationary bandit's capacity. In addition, for each stationary bandit, I gathered information for each year on whether they administered justice (dispute resolution covering marriage, land, property, witchcraft conflicts and other types of disputes) in their location, as well as whether whether they ran a fiscal administration. The tablet survey items for capturing these outcomes were respectively "Did the organization administer justice in the village?" and "Did the organization administer the village?" which, as was revealed in the study design, is used for tax administration when referring to armed actors. For the village, all stationary bandit organizations appear as if they provide basic security, so, while we collected a similar question, initially, we use the question "Was the effort that this organization provided to secure the village effective?" to reflect that many stationary bandits provided do not really provide security but only attempt to convince the population that they do.

Violence. To measure violence, I focused on attacks orchestrated by armed actors. For the support village, as well as for the mining site data, I am able to distinguish for each event whether it was organized by the stationary bandit of the specific location in which the attack took place (henceforth internal attacks), or whether they were organized by armed actors who were not stationary bandits in the location in which the attack took place (external attacks). In the paper, I focus on external attacks, which reflect the effort to capture a location. Internal attacks are much less frequent, and confound attacks made by a stationary bandit at his early years with attacks made by external armed actors. This is due to the fact that an armed actor frequently engages in arbitrary expropriations immediately after a conquest, to collect the so-called "butin de guerre" (war booty). This is also done in order to send a strong signal of toughness to the population they aim to govern.[50] External attacks are often territorial conquests (when a violent actor engages in

[50] Armed actors themselves refer to the strategy of sending a strong signal in the first day in order to deter oppositions to the armed group as "indoctrination to the group's ideology." This reflects that it aims to generate

violence *against another armed group* located in the contested location, not the villagers, with the aim of acquiring the monopoly of violence of the village), or attacks that are aimed exclusively at expropriating for the consumption of the armed actors, or attacks that are aimed exclusively at punishing villagers for collaborating with an enemy group.[51]

Household welfare. I also collected proxies for households' welfare. First, Eastern Congo is a bride price society, where liquidity constraints are a major obstacle to getting married. I thus observe for each year in the support village, the number of marriage ceremonies that took place. I also obtain the marriage history from the households themselves.[52] Second, I reconstructed the history of cattle acquisitions. Finally, since the population can migrate between villages, a way to capture welfare is to examine the location choice of households. I thus obtained for each municipality the number of immigrants every year. I further collected the year at which the households arrived in the current village.

Geographic data. Finally, with the geographic coordinates collected during the survey, I linked my data to geographical shapefiles I obtained from the Réferentiel Geographique Commun.[53] This source contains the map of the road network of the DRC, all airports (including small landing lanes), the location of forests, rivers, lakes, and the regional capitals. I compute the shortest distance of each village to the road, the lake, the forest, the regional capitals, Rwanda, and the closest airport. In the analysis, I use a dummy variable to indicate whether the distance to the closest airport is above the 50% percentile in the sample. The results are unchanged with the continuous variable.

B.2 Variable construction

In this section I describe my procedure for dealing with measurement error for the core variables in the analysis: taxation and stationary bandit.

Survey design, multiple sources, and triangulation. Even with the safeguards in the survey, measurement error is still possible in data collection due to recall imprecision or simple oversight

compliance, by providing information that villagers internalize. Source: author's own qualitative interviews with commanders of armed groups.

[51]From conversations with surveyors (not primed), almost all of the external attacks at mining sites during the coltan shock were conquests

[52]Both are highly correlated and I use the village variable, which does not hinge on a random sample with obvious survivor biases.

[53]See Référentiel Géographique Commun (2010).

of surveyors. By design, however, I have multiple sources that allow me to triangulate the data.

Household survey modules about the support village taxation and stationary bandits. I rely on multiple household modules (a module on armed groups episodes in the village as stationary bandits and a module on taxation in the village). The household security module asked each household about the details of each of all stationary bandits' episodes that took place in the village. The household tax history module asked each household what kinds of taxes were levied in the village, who initiated the taxation, and how much they need to turn in. The household respondent was encouraged to gather other family members to help complete modules that informed about the household. Thus, they are reliable references for village survey accuracy.

Village survey modules about the support village taxation and stationary bandits (a module on armed groups and a module on taxation in the village). First, information of stationary bandits (which includes the taxes they collected) is collected through village security module. Village experts were asked about the armed group history in the village, the taxes they collected, the years at which they conducted different types of activities, including administering the fiscal administration, the justice administration, and years of taxes, as well as other details. This module is mostly identical to the security module of the household. Second, details for any taxation episode in the village, for any type of tax, is collected from village tax history module. For poll tax, village experts need to recall the organization that levied the tax, the duration and the amount of tax. For other taxes, village experts need to indicate its existence in each armed group episode. The village tax history module is identical to the household equivalent module. Armed group information and taxation in mining sites is collected in different modules in Sud Kivu and Nord Kivu, which I explain in detail later.

Qualitative report. Surveyors needed to complete a lengthy qualitative report in each village to describe the armed group and taxes history, its rationale, and explain the data we see. Each surveyor was required to answer a series of questions about the village history, armed group history, tax history, conflicts between armed groups and people, etc. This qualitative report serves as a safeguard as well in case there is some technical issue during data collection.

Support village variable construction

First, for armed group episodes and poll tax in the village, surveyors asked the chief or other village experts about the armed group history and tax history. Then, surveyors collected the same information from a random sample of households. Therefore, household survey can serve as a check to confirm the existence of stationary bandit or poll tax. Using households as a tool for verification, I correct the armed group episodes in village survey. Specifically, if village security episode indicates the presence of armed group in a given year, but it is not supported in any household survey, then I trim the village security episode to exclude the presence of a stationary bandit in that given year - after verifying that it is also absent from the qualitative reports. Likewise, if no stationary bandit is recorded by the village security module in a given year, but all households reported the presence of armed group, then I add a new security episode to village survey. I verify the qualitative reports before making this correction. I apply the same correction to the poll tax in village survey. This revision has no bearing on the results of this paper.

Second, for taxation (tax on market, tax on road, and tax on mills), I use the fact that if there is taxation, there must be some organization or armed actor taxing, either armed groups or other authorities. Therefore, if there is no record of any stationary bandit in a given year in the village security module, the households, and the qualitative report, but there is evidence of taxation in the village tax history module, the village tax history record is considered false - there are also cases of local state authorities taxation (village chiefs, chefferie chiefs, territory administrators), but I exclude these actors from the stationary bandit analysis as I discuss in the main text and section B.1. In this way, I frame village tax episodes inside armed group episodes to complement the taxation data of armed actors, and thus obtain the history of taxation by armed actors. This revision has no bearing on the results of this paper.

Third, in three cases, the village taxation history reports tax true episodes (as confirmed by the village qualitative reports) outside of the armed group episode that is recorded by the household survey, the village survey. It is also possible that the armed group history is complicated and the surveyor might not know how to encode it into tables. Thus, in this case, I add a stationary bandit episode correspondingly. Otherwise, I frame the tax episodes following the approach mentioned in the previous paragraph. Only three villages of Sud Kivu are affected by this revision (villages A32, A35, C30). This revision has no bearing on the results of this paper.

Mining site variable construction

For mining sites information, I apply different procedures to Sud Kivu and Nord Kivu, which was implemented on an improved survey platform (FORMS 32K, which is now obsolete, was used for Sud Kivu, against ONA and ODK collect for Nord Kivu).

In Sud Kivu, I designed two modules for mining sites. The first module gathers general information, such as types of principal minerals, entry tax, roadblocks, external attacks, etc. The second module is designed for more details, such as the armed group episodes within this site, security service, etc. Both modules provide indicators of taxation, but only the second module has information regarding stationary bandits. Therefore, for those observations with no armed group data but some tax records in either module, I correct the stationary bandit dummy to indicate that a stationary bandit was present. The main conclusions hold if I make no revision or only fix part of these problematic armed group episodes. This revision accounts for 8.7% of mining sites * year observations, and has no bearing on the results of this paper.

In the Nord Kivu survey, which is almost identical but contains additional armed group information, surveyors collected two types of data for armed groups: a module entered during the day directly on the tablet, and a "historical" module, entered on paper to expedite the process of data collection and reduce mistakes by providing a visible user friendly table, but then copied at night in the tablet survey application. In both modules, surveyors record the armed groups in mining sites, but only the module entered first on paper has information about their taxation. I use the stationary bandit information entered in the module that is originally on tablet to generate stationary bandit indicator. I use the data for the module entered on paper (the historical module) for correction. If stationary bandit and taxation both exist in the module entered originally on paper, but no armed group is recorded in module entered directly in the tablet, I fix the stationary bandit indicator to include this unrecorded episode. This revision accounts for 9.7% of mining sites * year observations, and has no bearing on the results of this paper.

C Data based on recall: measurement error?

This paper relies mostly on recall data. Recall data can contain measurement error. Is the strategy immune to recording particular answers in coltan locations during the coltan shock?

C.1 Track record of recall data collection and lessons

While many municipalities lack written records of administrative data, historical events are meticulously kept and transmitted orally across generations in Eastern Congo. The strategy proposed in this paper is, in fact, not new, and responds to the cultural context of Eastern Congo. Historians, anthropologists, and economists have a long track record of working with this cultural feature, called "oral history," to learn about the past, and discussing the biases that may arise (Newbury, 2009, Vansina, 1985).[54] Villages in Eastern Congo usually have a group of "elders" responsible for narrating the history of their community. Elders usually transmit the historical information of their municipality and tribe in community meetings that the villagers attend, the "Barza."[55] The safeguards that I describe next in this section were designed precisely in response to the concerns that may arise with the type of recall data that is transmitted in oral history societies.

The challenges associated with the collection of historical recall data are also well-known across social sciences, including in economics, health, and psychology (de Nicola and Gine, 2014, Kjellsson et al., 2014). A first established result is that as the time period of recall widens, self-reported answers from the past converge to the mean of the real distribution, thus decreasing its variance (Tourangeau et al., 2000). This implies that the magnitude of measurement error increases in the recall period, and that recall data likely underestimates historical variance as well as the magnitude of the response to external shocks (attenuation bias). Larger measurement error and lower variance in the years of the coltan shock work against finding an effect of the coltan shock.[56] A second established result is that bad years are recalled worst (de Nicola and Gine, 2014, Tourangeau et al., 2000). One may worry that since the coltan shock had positive economic impacts, respondents may recall better events in coltan locations during the coltan shock. Note, however, that while incomes increased, violence due to contestation among stationary bandits also increased. Hence individuals may recall with different degrees of precision (or bias) events around the coltan shock. I discuss this concern in the following section.

The literature also suggests how to reduce recall error. First, since respondents may misplace events over time (telescoping), researchers in social psychology frequently use time cues.[57] The literature in psychology suggests that times cues reduce measurement error about the timing of events (Brown et al., 1986, Conway and Bekerian, 1987, Dex, 1995).[58] Second, de Nicola and Gine (2014) find that recalling changes is easier than recalling levels. Kjellsson et al. (2014) document

[54]See Vansina (1985).

[55]Furthermore, every evening, the "chief" of the household narrates the history of the family to his descendants around the fire. There is a very strong norm of transmission, precisely because these communities usually lack written records.

[56]Note that recall data is, on average, correct — the reported distribution is centered around the true mean.

[57]Time cues are common knowledge events that are designed to allow the respondent and surveyor to identify the time at which a given reported event occurred.

[58]de Nicola and Gine (2014) compare surveys with and without time cues and find no significant improvement as a result of time cues, but note that irrelevant time cues can increase measurement error.

a similar finding for events vs. levels. Finally, the literature suggests that male household heads who are the owners of the productive assets provide more accurate responses (de Nicola and Gine, 2014). I next comment on the safeguards I used in light of the existing track record.[59]

C.2 Safeguards to reduce the measurement error due to recall

Safeguards against surveyors leading to particular answers in coltan locations during the high coltan price years

The first safeguard I put in place focuses on surveyors' biases. The oral history literature warns against the risk that surveyors may have biases, which could influence how questions are asked, priming, and even how they are recorded. Surveyors' biases may be a concern, for instance, if surveyors are expecting specific answers for coltan villages during the coltan shock. To reduce this concern, the data collection was designed as double-blind. Surveyors did not know that the study of the price shocks was the goals of this study. Official communications of the project mention that the major objective of the project is to reconstruct the socio-economic history of the province. There are three levels at which information was controlled to prevent surveyors to lead to differential responses.

- **Training:** all surveyors were informed at training that the purpose of the research was to reconstruct the economic history of the villages of the Kivus.
- **Official documents:** all official communications of the project with the surveyors, and with the state authorities (for authorizing the study and to present at checkpoints) mention that the major objective of the project is to "reconstruct the socio-economic history of the province," and avoids any mention to the coltan shock. The legal document authorizing their activities refers to the project as "Economic history of the Kivus." Figure F.18 presents the said document.
- **Surveyors' manual:** surveyors carried a manual of instructions that specifies what actions they must take, what language they must use, and the purpose of the research. The manual specifies (and emphasizes in bold) a core part of the consent text:

[59] Another concern with this literature is survivor bias. Since the unit of analysis is the municipality, and municipalities do not disappear over the period of study, this is not the major threat to validity in this paper.

> “The goal of this research is to reconstitute the social and economic history of the rural areas of Sud Kivu (Nord Kivu for the extension). The life of women and men of Sud Kivu is very poorly known outside the province, and this absence of information and knowledge entertains bad perceptions about the province. This project aims to bring a solution to this problem, by reconstituting in a rigorous and scientific manner the history of the province, in order to promote a better knowledge about the East of the DRC and its inhabitants in the world. In order to reconstitute such history, we are asking questions to habitants of the province about their past life. If you accept to participate to this research, we will ask you questions about your life, your work, your marital status, and the history of your village, and your testimony will add to all others to help us reconstitute the history of Sud Kivu (Nord Kivu for the extension).”

Last, it is worth noting that both in training and in the manual, a core, yet invisible part of the study was to enforce maximal precautions with the collection of recall data. The following extract from the surveyors’ manual reflects the care, and emphasis with this precaution:

> “The interpretation we have of our own life is often false: CAUTION not to rely on the words of the respondent but instead always dig further. Respondents tell us stories. It is their own stories. As stories, these are narratives, interpretations of facts and causes that led to these facts. In most cases, what the interviewee tells you is an interpretation and is subject to considerable bias. Over time, the subject may change his/her interpretation depending on the mood and end up convinced of it. This is particularly serious for questions like: Why? Your duty is here digging, always digging to get the purest of respondent information. Sometimes you will learn something of respondent without him having the impression that you learn.”

Safeguards to reduce likelihood of recall error, especially non-classical error

The second group of safeguards I put in place aimed to reduce eyewitnesses’ biases and recall error. Unlike usual recall studies, this survey is not based on one brief conversation. The data collection activities that are required to create one statistical village*year observation took 7 meticulously planned days in each village. I designed such activities to address measurement recall error about *what* happened, and measurement recall error about *when* it happened.

- **Triangulation methods:** Recall error may be larger for events further in the past, and bad times may be recalled worse. Because the main outcomes I collect are about a common event, not about individuals, I can rely on triangulation methods used in the qualitative social sciences, which consist of verifying information from multiple sources (Rothbauer, 2008). Surveyors first collect information directly from a group of 5-10 individuals (including chief, elders, and mining sector experts). As I described in Section 3, surveyors train these individuals to gather and assemble information, and monitor each of them for 7 days. The final interview with them in the seventh day is the main data entry for the village. In addition, surveyors conduct 8 in-depth, 4-hour long surveys in private in randomly selected households (6 households for North Kivu). In each household, they reconstruct the history of the village with a randomly selected adult.[60] Furthermore, the surveyors conduct qualitative surveys with various actors in the village, which they then type for the researchers to verify individual observations.[61] Triangulating information from multiple sources allows the surveyors to reduce the variance of their posterior beliefs — by the law of large numbers. Triangulation also allows them to verify information in private from the average villager, since the elite may have its own agenda. This approach allowed to secure that before the last day interview with the history specialists, surveyors had no doubts about the history of the village, including knowledge of what facts may be sensitive. By the end of the week, learning had been effective and additional sources brought no change in priors.[62]

- **Using how the survey is administered to reduce recall error:** I designed the survey so that questions focus on transitions, rather than levels, and events that are easy to memorize. This approach proved to be very effective at extracting memory from respondents. It evoked life memories in such a way as to minimize transitions between different groups, which usually wastes mental resources. Surveyors ask: "Was there ever a stationary bandit in this village?" If yes, the surveyor proceeds: "let's begin with the first of these organizations" and focuses on identifying well the group and its properties. Once the memory of one group was activated, the "marginal cost" of recalling additional events about that group was close

[60]For village history questions, I allowed respondents to be helped by other household members.

[61]In the reports, surveyors note explanations for patterns in the quantitative data.

[62]An important cultural factor that may limit replication of this study in other civil war contexts outside the Congo is that individuals are very communicative, especially about armed groups.

to zero, but transitioning between groups was the costliest and could exhaust respondents quickly.[63] In addition, using a "respondent summary table" that allows them to visualize the entire respondent's history and that surveyors have in sight during the entire interview, surveyors visually contrast in each survey module the year of the different events as they were reported. Surveyors first create the summary table of years to relevant events in the life of the respondent, then proceed to ask all other questions, inspecting and completing the "respondent summary table" as they progress in the interview. The summary table provided a strong check against recall error.

- **Time cues:** To reduce measurement error on the years in which events occur, I designed a set of time cues that reflects the events that individuals remember equally across villages in the province, and that can be used to locate transitions in history. Surveyors use these time cues at the time of administering surveys. The time cues reflect well-known historical events that affected the whole region. To develop these cues, I consulted surveyors, mining professionals, and local historians.[64] As an alternative method to use time cues to cross check retrospective data, I trained surveyors, and designed the survey instruments, so that interviews are conducted at all times with a summary of the history of the respondent in front of the respondent and the surveyor. The surveyor's manual illustrates this approach:

  > "For each question, you are asked what year it is. It's so important that I made available to you a paper of time indices with historical events. For each question, you must use the three sources to confirm the year. It is ESSENTIAL. The respondent will easily assign wrong years, especially in rural areas. They may excessively use years like 1990 or 1985. You have to dig using the temporal indices. Tip: Use the pins about the history of the individual every time! You have in front of you the years in which he was in a given village, with a given wife, with a given field. Use them! It is the pillar of the respondent."

- **Time cues and the coltan shock:** I use the regional coltan spike as the time cue for the

[63] Reflecting the general approach to ask retrospective questions in this project, the surveyor manual reads: "It is a RETROSPECTIVE survey: We want to know the past of the individual. So we must at all costs avoid phrases like 'Are you married¿ Or 'how many fields do you own?' [...] Instead ask, 'how many times have you ever married in your life?' [...] 'have you ever worked in the mining sectors? If so, tell us about your first activity in these sectors' 'We are here in the village. But have you ALWAYS lived here? Let's start with the village 1' "

[64] A respondent may not know the year at which she got married, but she always knows if it was after Mobutu, and before the RCD took Bukavu, in which case it could only be 1997.

year 2000. Everyone interviewed in the province remembered the coltan spike. It was an event difficult to ignore when talking about the recent past. Using this time cue also helps circumvent the problem that respondents in coltan areas will be more likely to mistakenly assign events to the year 2000—it serves as a common benchmark. Consider events that occur in 1999 and 2001. Suppose respondents in coltan locations systematically assign a proportion of such events to the year 2000. Using the year of the spike as a benchmark during the interview process to compare transitions to the benchmark helps them correct the year they answer. Respondents may tend to mistakenly assign events/transitions to the year 2000, but when benchmarked, this allowed to identify the correct year. One may be concerned that the coltan spike was experienced differently by communities that had coltan. Note that the respondents are first asked to map the set of events, for which the dates of transitions are needed. Only then, the surveyor asks, if necessary, whether the event/transition was before or after the coltan shock. It could also be that individuals in coltan locations today remember more clearly the coltan shock and thus the time cue reduces measurement error especially in coltan locations but not in gold locations. This could increase the statistical power to detect true effect sizes that are positive, when estimating the effect of the coltan shock, but it is unlikely to induce a bias in the estimation of the coltan shock in such a way that it yields a larger estimated effect size.

- **Working memory measures:** In Sud Kivu, at the start of each interview, households played a working memory game, aimed at eliciting their familiarity with numbers, and were as well asked to give the number of years elapsed since well-known events. In Nord Kivu, I introduced another game called Lumosity memory matrix at the end of the extension survey. It is a more standardized test for working memory and can be regarded as an improvement to the previous game in Sud Kivu. A group of tiles on a grid was shown to interviewees, and they were asked to recall the location or shape in a few seconds. Although these two games were different, they both elicited interviewees' short-term memory and their ability in temporary information processing. I construct a score respectively for each of these two games, both normalized respectively, and use it as a proxy for the reliability of the historical answers of the survey as well as weights in a weighted regression to replicate Specification 1. The results are unchanged by the weighting. Moreover, the results also hold by using only Sud Kivu or Nord Kivu sample, which indicates that working memory measures from different games are comparable.[65]

- **Selection of respondents:** de Nicola and Gine (2014) find that male adults exhibit a smaller recall error. I administered the 8 household surveys on adult male respondents.

C.3 Measuring the measurement error due to recall

In this section, I use the data and external sources of data to measure the recall error.

First, I compare the data to the well-documented historical waves of the conflict. Figure F.9 and F.19 plot respectively the survey-based measures of armed groups' presence and of attacks on years. The figures reflect well the well-documented evolution of the industrial organization of violence. Prior to 2000, Figure F.19 shows data consistent with the historical evidence: the First and Second Congo War brought a variety of armed groups, external, regional, and village militia, which were fighting for various purposes. In the first Congo war, the Tutsi-led AFDL led a rebellion to overtake Mobutu in Kinshasa. Figure F.19 shows that the data confirms this: in 1996, the attacks of the AFDL spike. In 1998, the newly formed Tutsi-led RCD factions emerges to overthrow the then President and former AFDL leader, Laurent Desire Kabila. Figure F.19 shows again a contemporaneous spike in attacks by the RCD and the Hutu FDLR in 1998 at the start of the rebellion. Furthermore, as the RCD is expanding its territorial control, a large number of local mobilizations occur, under the license of Mayi-Mayi groups.[66] Such groups also appear starkly in Figure F.19, emerging in 1997 (in response to the AFDL), but spiking in 1999. This summarizes the dynamics of the environment prior to the coltan shock.

Following the Sun-City peace agreement, most armed groups slowly vacate the area—many integrate the Congolese army battalions (FARDC), but keep their old structures of command (Stearns et al., 2013). Figure F.19 also shows this pattern. Furthermore, the figure also shows that the Hutu FDLR takes advantage of the security vacuum generated by the Sun-City peace agreement a few years later (see for instance Stearns (2011) and Nest et al. (2011)) and increases their presence in the years following Sun-City. The figure shows that when the operation Kimia II goes under way, which is a military coalition of the FARDC, the Rwandan army, and the United

[65] See Tables F.2 to F.14 in the online appendix and Section E.

[66] While some are village self-defense groups, others have a regional aim, including ideological narratives of anti-Rwandan imperialism that they inherited from their training under the Cubans in the 1960's. One of the Mayi-Mayi subjects of the qualitative interviews I conducted for this project, for instance, was flown to Cuba for a 3 year training to fight alongside the Cubans in the Mai Mulele rebellion of 1964.

Nations, the FDLR increases their attacks on the population. In Sánchez de la Sierra (2018), I analyze in detail this shock. The FDLR, who were acting as stationary bandits in the villages they controlled, realizing they have no chance of military success, see their time horizon shrink, and turn to predators on their own tax base. This accounts largely for the spike of attacks exactly as the Kimia II operation is announced in 2009.

Finally, Figure F.19 also shows the rise of the Raia Mutomboki in 2011. As is known, the Raia Mutomboki emerged in 2011 in the district of Shabunda, largely responding to a security vacuum left by the FARDC, whose battalions were reshuffled precisely to conduct the Kimia II operations in FDLR territory. With scarce personnel, the FARDC left vast areas basically stateless, especially Shabunda. As a result, banditry increased, especially as Shabunda villages started receiving attacks from the FDLR units that were located in the forest of Shabunda. There are many such units across the forest in the area. The Raia Mutomboki, standing for angry population, emerged as a local self-defense group to fight the FDLR, who were perpetrating massacres, and slowly grew to one of the largest regional militia of Eastern Congo.

Second, I use an alternative data source for violent events, ACLED, to examine the bias in the data.[67] I assign the number of attacks recorded that year in ACLED in the proximity of the municipality, for each municipality-year observation.[68] I first compare this data to the survey data on attacks at the municipality graphically.[69] Figure F.20 shows that the ACLED dataset systematically reports *fewer* battles than the current survey, and that such a gap is especially strong during the Second Congo War. The ACLED data thus plausibly under-reports waves of violence associated with well-documented waves of the conflict. This comparison reduces the concern that the survey data suffers from serious under-reporting. Having matched the two data sources, I next address measurement error issues using statistical methods. I examine the correlations between the two data sources, and I replicate my results using the available ACLED data. Table F.17 implements a linear probability model to regress whether an attack was recorded

[67]This dataset has been used for the DRC context, notably by Maystadt et al. (2014), Koenig et al. (2017), and Parker and Vadheim (2016)

[68]I assign geo-coded violent events of ACLED to circles of varying diameter around the survey municipalities of this paper. ACLED data focuses on violent events and is based on news reports. The ACLED dataset contains 3,500 violence events since 1997, coded by type of event. When an event falls in circles of more than one village, I allocate the event to all corresponding villages. ACLED also reports details about the type of event. To construct the variable "attack" from ACLED, I take the total of events recorded by ACLED, and subtract all events that are not attacks for each year*village observation. The non-violent events are: strategic transit of troops, riots, non-violent transfer of territory, and whether an armed group changes a headquarter location.

[69]The union of attacks at the support village and attacks at the mining sites.

by ACLED on whether an attack was recorded by the survey. Columns (1)-(8) present the results of respectively regressing the matched ACLED violent events that fall in a given year within 1km, 2km, 5km, 10km, 15km, 20km, 25km, 50km from the municipality. The two proxies for attacks are strongly related: 5 of the 8 distances have a coefficient significant at more than 5% level. Events that fall within [10km;25km] of the village are strongly correlated with the survey data. Finally, Table F.18 also presents the results of Specification 1 using ACLED events instead of the survey as a dependent variable. The result is identical to the paper's result. The average coefficient size using ACLED is 13%, while the coefficient using the survey data in Table 1 is 14%. The results suggest that there is no bias due in the survey data.

D Persistence

Table F.3 in this online appendix presentS the analysis on persistence. The table shows the estimates from a linear probability model regressing the presence of a stationary bandit on the lagged values of the main regressor, $C_j \;\; p^{US}_{c,t}$. Columns (1)-(4) replicate the baseline specification, but include the lags. The coefficient on the first lag of $C_j \;\; p^{US}_{c,t}$ suggests that the coltan demand shock led to the emergence of stationary bandits which persisted for at least two years after the shock. However, the results in Columns (1)-(4) may not be due to persistence, but simply to the coexistence of a contemporaneous and a delayed effect of the coltan shock. To capture the role of autocorrelation in the dependent variable, Column (5) includes the lagged dependent variable as a regressor and implements Arellano-Bond GMM estimation—I choose Arellano-Bond GMM estimation instead of standard OLS with fixed effects to avoid creating a Nickell bias (Nickell, 1981). Inclusion of the lagged dependent variable renders the lags of the coltan shock statistically insignificant and close to zero, while the lag of stationary bandit is significant at the 1% level with magnitude of .74. This suggests that the coltan shock led to stationary bandits, and stationary bandits are persistent. Column (6) adds the second lag of stationary bandit and the results are unchanged. To rule out that continued local demand for coltan accounts for the persistence of stationary bandits, Column (7) includes the average price of coltan paid by traders locally at the site level, collected in the survey. To minimize the risk that measurement error drives the results, I averaged the yearly values of the price of coltan for all support villages in the sample. When I include the log of the local price of coltan, interacted with coltan mineral endowments as a control in Column (7), its coefficient is positive and statistically significant. However, the lag of stationary bandit remains of similar magnitude and statistically significant at the 1% level. This suggests that the persistent high local price in the aftermath of the coltan shock cannot, alone, explain the persistence of stationary bandits. Finally, Column (8) implements a 2SLS panel regression of stationary bandit on its lag, where I instrument the first lag of stationary bandit with the first lag of $C_j \; p^{US}_{c,t}$ to circumvent endogenous location of stationary bandits. Results are unchanged.

E Robustness checks

Tables F.2, F.5, F.6, and F.14 present the main robustness checks for each dependent variable. Each table reports 12 robustness checks, in addition to specification 1, shown as benchmark. The coefficient of interest remains statistically significant and of the same sign in most specifications. At the end of this section, I also present an additional robustness test linked to the choice of the time window for analysis.

First, Column (1) implements specification 1.

Second, the results may reflect pre-existing mineral time-trends. To account for this, Column (2) includes mineral time trends.

Third, region specific year level shocks may coincide with the coltan shock, which would be threatening for validity especially if coltan endowments concentrate in particular regions. Column (3) thus includes region*year fixed effects.[70]

Fourth, the results may reflect spurious correlations stemming from underlying patterns of autocorrelations in the data. To rule this out, Column (4) includes leads and lags of the regressor as a falsification exercise — the coefficient on the lead is zero and not statistically significant.

Fifth, the fixed effect estimator may be sensitive to deviations, and the results may stem from the choice of specification. Thus, Column (5) implements the Arellano-Bond GMM estimation to allow for a dependent variable as well as the inclusion of municipality and year fixed effects.

Sixth, the new specification may not be robust to linear mineral trends. Column (6) thus implements Arellano-Bond GMM with mineral time trends.

Seventh, to verify that the results are concentrated around local airports, Column (7) includes

[70]There are 14 regions in the Provinces of Sud Kivu and Nord Kivu, these are called Territoires, and have the following denomination: Kalehe, Idjwi, Mwenga, Shabunda, Walungu, Kabare, Fizi, Uvira, Walikale, Masisi, Rutshuru, Beni, Lubero, Nyiragongo.

the interaction with the dummy indicating distance to local airports, $C_j\ p^{US}_{c,t} D^a_j$, as well as the corresponding interaction term $p^{US}_{c,t} D^a_j$.

Eight, the results might reflect differential timing of conquest of villages close and far from the road, which may correlate with mineral endowments. To account for this, Column (8) includes in addition the analogous interactions for the distance to the road, $C_j\ p^{US}_{c,t} D^r_j$ and $p^{US}_{c,t} D^r_j$.

Ninth, the results may reflect non-classical measurement error in the self reported variables in the survey. For instance, the saliency of the coltan spike may prime respondents of coltan areas about the year 2000 differently than respondents in other areas. This could increase the precision in coltan areas compared to the rest of areas, artificially producing significant differences compatible with a true effect of size zero. This is especially worrisome because this population may not be very familiar with numbers and years. To account for this possibility, I collected measurements of working memory in each village of Sud Kivu and Nord Kivu. In Column (9), I implement a weighted regression using working memory scores as weights. To construct measures of working memory, I implemented two standard working memory tests in Sud Kivu, and a standard Lumosity memory matrix game in Nord Kivu. In Sud Kivu, I first constructed a sequence of 7 randomly selected digits between 1 and 9. I then asked the surveyor to read the sequence sequentially, and ask the respondent to repeat the sequence of numbers as the surveyor increases its length. In the end, once the surveyor has spoken the entire sequence, I then collect the responses. I assign a score indicating the proportion of digits that the respondent answered correctly. Second, I asked the respondent to tell how many years have elapsed since the departure of President Mobutu. Since the answer to this question is popularly known, I simply code whether they are right or wrong in a dummy variable. I also include deviations of 1 years above or below as correct answers. The overall measure of working memory is a weighted average of these two variables, where I assign equal weights to the answers for each question, and normalized to standard distribution (mean zero, standard deviation one). In Nord Kivu, I show each interviewee a group of tiles on the grid, and then ask them to recall the location and the shape in a few seconds. I compare their answer to the correct one and record the number of correct locations. After the game, I construct a total score for the game, normalized to standard distribution as well. This standardized game is an improvement of the previous game in Sud Kivu, and the result is unchanged by using different measurements respectively or together in the pooled sample.

Tenth, Column (10) replicates the main specification, but assumes that cross-diagonal elements of the variance-covariance matrix are zero (no clustering of standard errors).

Eleventh, since the coltan shock occurs in one year, and coltan municipalities may be clustered around administrative divisions, year regional shocks could lead me to underestimate the true standard errors of the coltan price coefficient. To account for that, Column (11) clusters at the region*year level.

Twelfth, while the world price of coltan is a useful source of exogeneity for local demand conditions, the mechanism really operates through local demand. Column (12) thus instruments the local price of coltan with its world price.[71]

Finally, Column (13) replaces the time invariant coltan (gold) endowment dummy with an indicator of past coltan (gold) output, to account for the fact that some mines were more likely more intensively exploited than others prior to the shock. To construct the indicator of output, I gather the yearly output for each mining site between 1995 and 1999. Since output is very noisy (a continuous measure based on recall), and the mineral for which it is collected has a large proportion of mismatches, I construct a dummy for each year that a mine has positive output. I then compute the proportion of years in which the mine was active since 1995. I use this proportion to interact it with the world price shocks, instead of the time-invariant measure of coltan or gold.

Since the choice of years can be arbitrary, I run specification 1 for each possible combination of start and end year, and report the 116 coefficients and confidence intervals thus obtained. Figures F.4 and F.5 report the coefficients and confidence intervals for two sets of regressions run separately—regressing on the main coltan interactions, and on the main gold interactions.

To further account for spatial and time correlations that would lead me to wrongly estimate the standard errors in the main specification, I conduct randomization inference exercises to produce the counterfactual distribution of parameter sizes under H-0 of no effect. To tackle spatial correlation, I randomly re-assign mineral endowments to sites. To derive a reference distribution, I generated 20,000 random assignments to coltan endowment (0 or 1 for each site) following properties of the empirical distribution (the proportion of sites that have coltan). For each simulated assignment, I re-estimated the main coefficient, $Coltan_i \ Pc_t$ and stored it. The figure presents the distribution of coefficients estimated using the simulated coltan endowments. To obtain a p-value using the new reference distribution, I compute the relative mass of coefficients derived using the

[71] I obtained the site level local price of coltan through the survey by asking villagers to reconstruct the price time series during the week of work. Since the data is of poor quality at the village level, I nonetheless can average the local price by year across the region to circumvent the high rates of missing prices and "do not remember" observations. In this specification, I thus use the province-level yearly average of the reported prices.

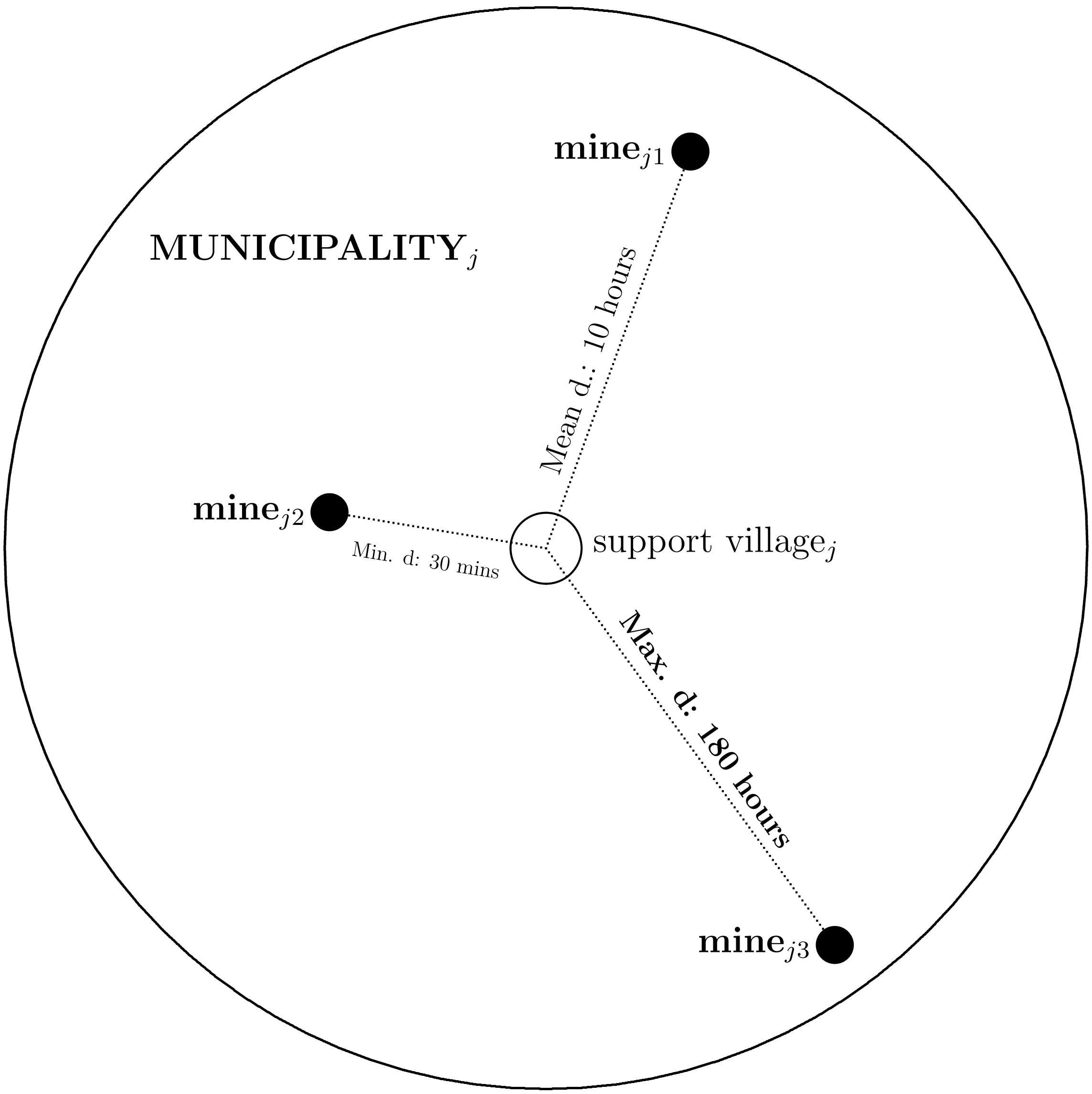
simulated endowments whose value is larger than the value estimated using the real endowments. Figure F.6 shows the resulting distribution. The distribution of estimated coefficients is centered at zero — since the treatments are fictitious — and the estimated p-value is 0.0002.

I then tackle the problem of common shocks that may simultaneously affect all coltan sites alike, which could lead me to underestimate the true standard errors. To derive a reference distribution, I generated 20,000 random assignments of the empirical coltan prices to years. For each simulated assignment, I re-estimated the main coefficient, $Coltan_i\ pc_t$ and stored it. The figure presents the distribution of coefficients estimated using the simulated coltan endowments. To obtain a p-value using the new reference distribution, I compute the mass of coefficients derived from the simulated endowments whose value is larger than the value estimated using the real endowments. Figure F.7 shows that the resulting distribution is bi-modal and centered below zero. This is expected, since treated sites are used in the simulation and because one of 12 prices is an outlier (the price that really occurred in 2000) and thus for simulations in which the price is assigned to another year than the year 2000, the majority, the estimated coefficient is negative. The estimated p-value is 0.0001.

I finally use a theoretical data generating process for the prices. To derive a reference distribution, I generated 20,000 random vectors of prices on years randomly drawn from a uniform distribution with mean equal to the empirical mean. Figure F.8 shows the resulting reference distribution and the corresponding p-value, and the results are analogous.

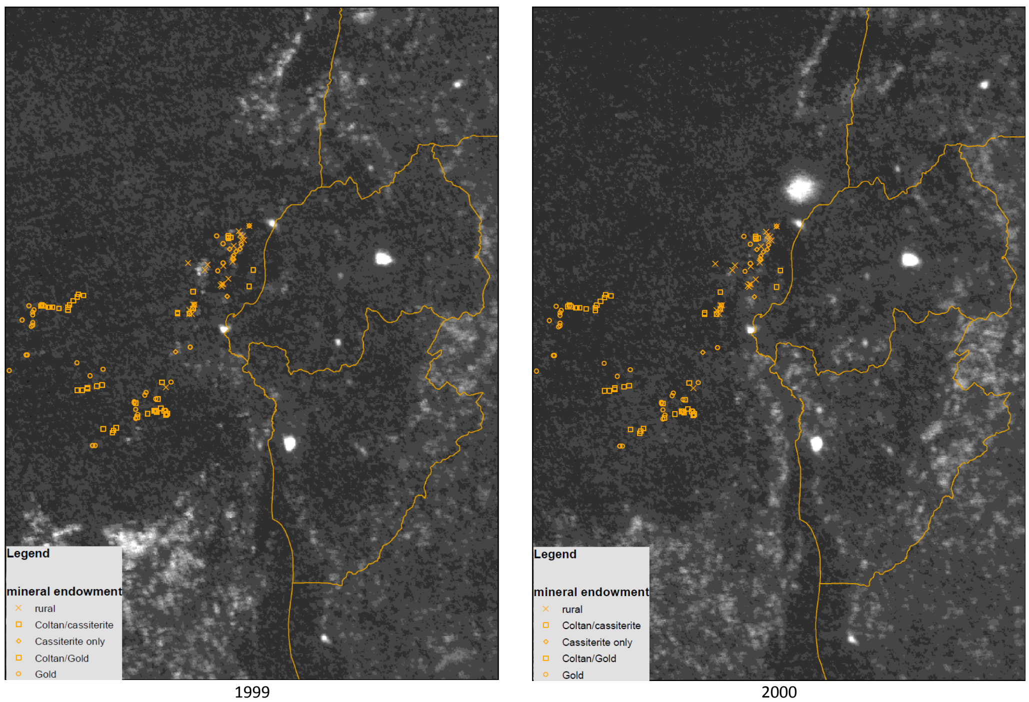
F Figures and Tables of the Online Appendix

Figure F.1: Microeconomic environment—The structure of the typical municipality



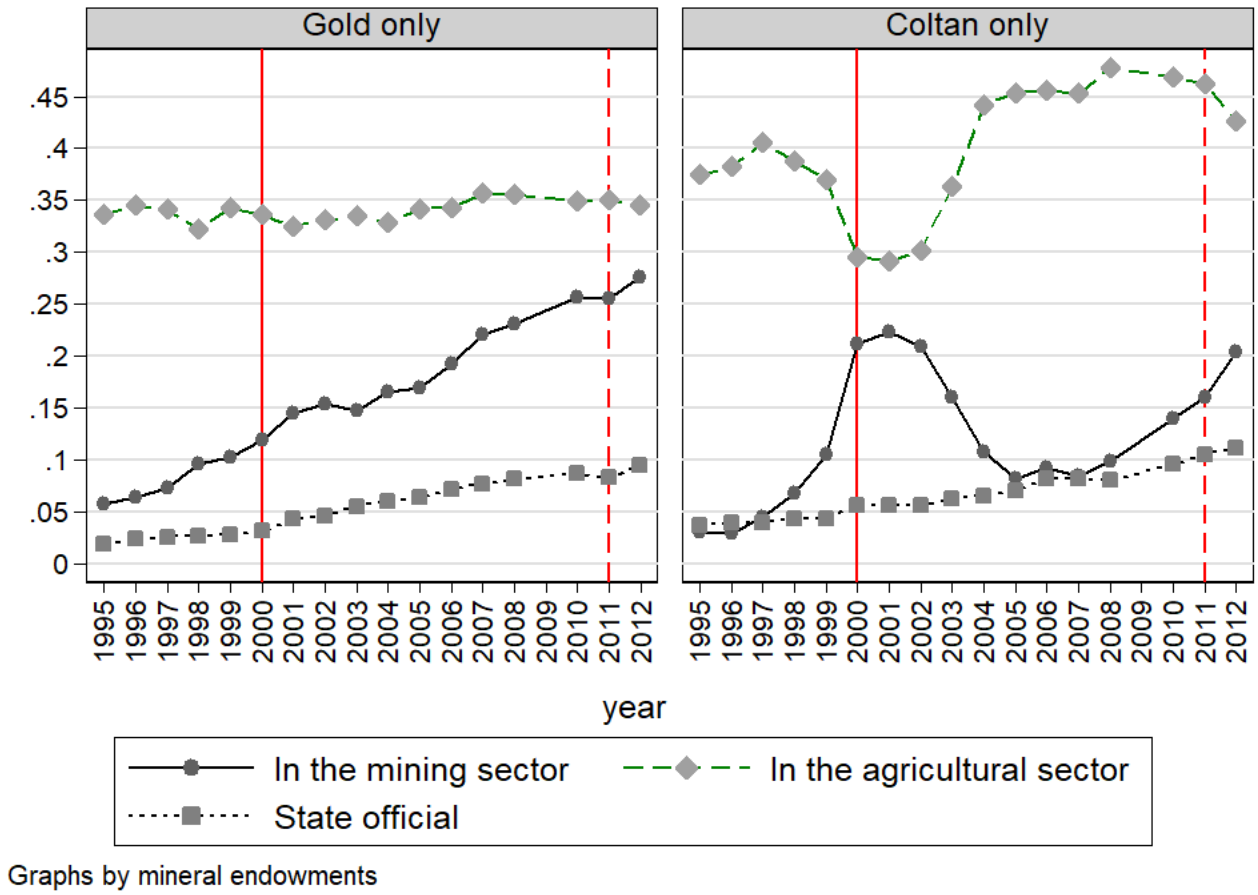
Notes: This figure presents the structure of a typical municipality. A municipality is composed of land, one support village (the historical village agglomeration in which households live), and mines—mines are located where minerals were discovered, which often does not correspond to the historical village agglomeration. The figure also reports the minimum, average, and maximum distance between the support village to a mining site, recorded in walking hours—most of the time mining sites are only accessible by foot, and passing first by the support village.

Figure F.2: The coltan price shock from satellite



Notes: This figure presents satellite imagery of the survey region at night. Support villages of Sud Kivu are marked with orange squares, circles, and crosses. The major mineral endowments of the sites attached to each of the support villages are as indicated in the figure legend. The left image shows the average cloud free lights captured by NASA-NOAA satellites from the survey area in 1999. The right image does so for 2000. International borders are drawn as orange lines. The DRC is on the left of the vertical line, and from North to South are Uganda, Rwanda, Burundi, Tanzania on the right of the line. In the year 2000, lighting increases in the main city of North Kivu (Goma), the trading hub for coltan trade. As the price of coltan boomed, economic activity increased around Goma.

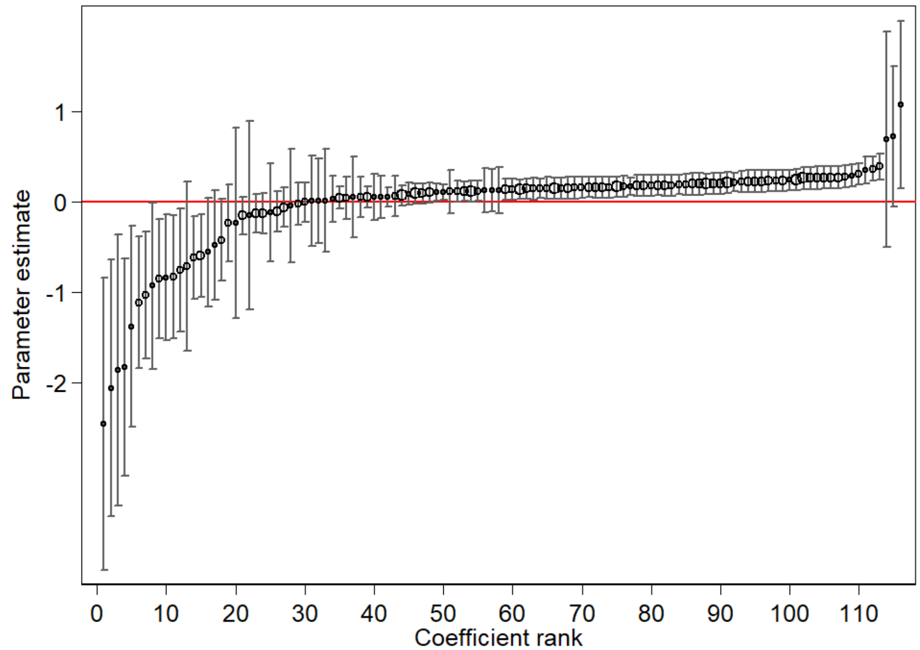
Figure F.3: The coltan demand shock and sector employment shares



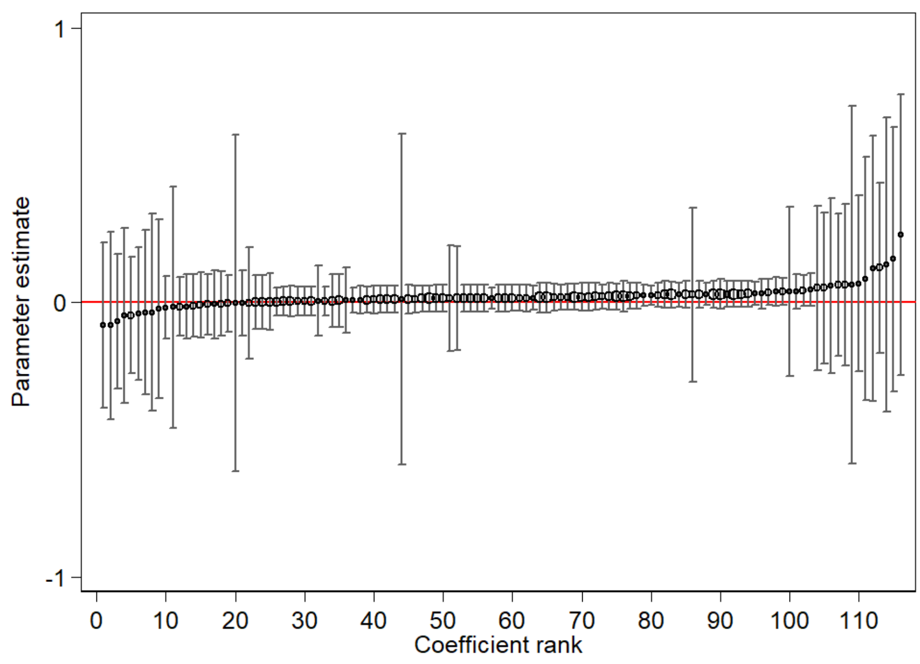
Notes: This figure plots the proportion of respondents of the household survey who work in the mining sector, agriculture, or in the public sector, by year. The solid line indicates the proportion of respondents who work in the mining sector, the dashed line indicates the proportion of respondents who work in agriculture, and the dotted line represents the proportion of respondents who work as state officials in the public sector. Solid, red, vertical lines indicate the timing of the large coltan price shock (year 2000) and the start of the small, but more persistent, coltan price shock (year 2011).

Figure F.4: Coefficient on coltan*price of coltan, all time intervals. Dependent variable: extensive margin index

PANEL A: Mines



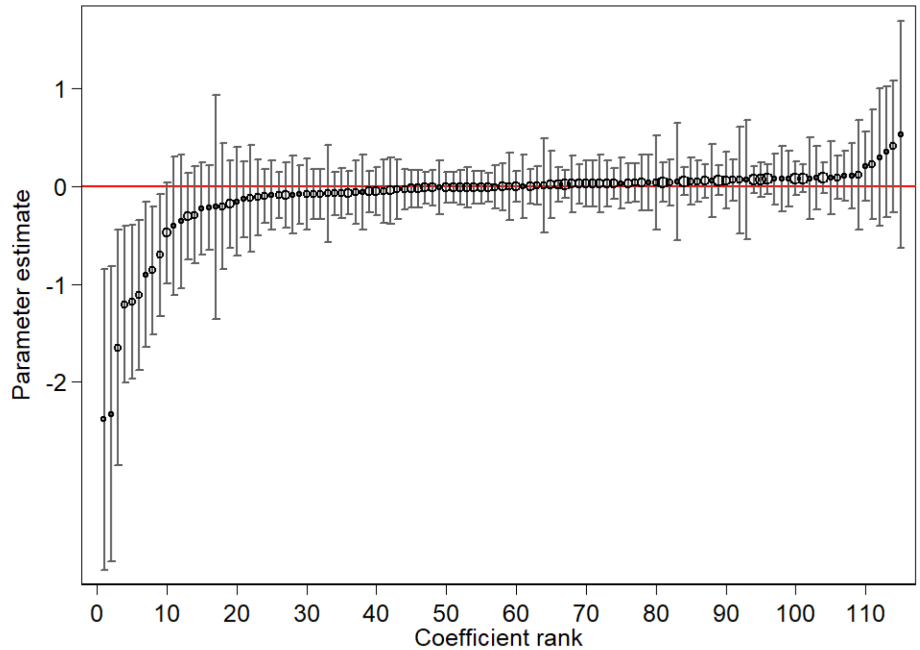
PANEL B: Villages



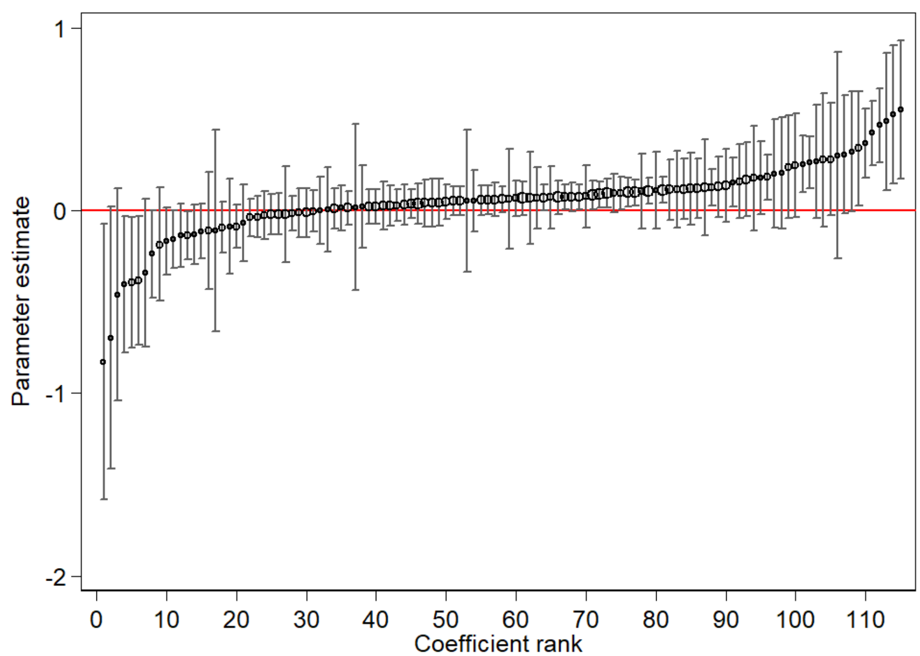
Notes: This figure plots the estimated coefficients on coltan endowment, interacted with the world price of coltan, from specification 1 using all possible time intervals. Intervals indicate 95% confidence intervals. The size of the symbol on the coefficient estimate is proportional to the sample size used for that particular estimation, which depends on the start and end years for that particular regression. Panel A presents the mine-level results, collapsed at the level of a municipality-year. Panel B presents the support village-level results.

Figure F.5: Coefficient on gold*price of gold, all time intervals. Dependent variable: extensive margin index

PANEL A: Mines

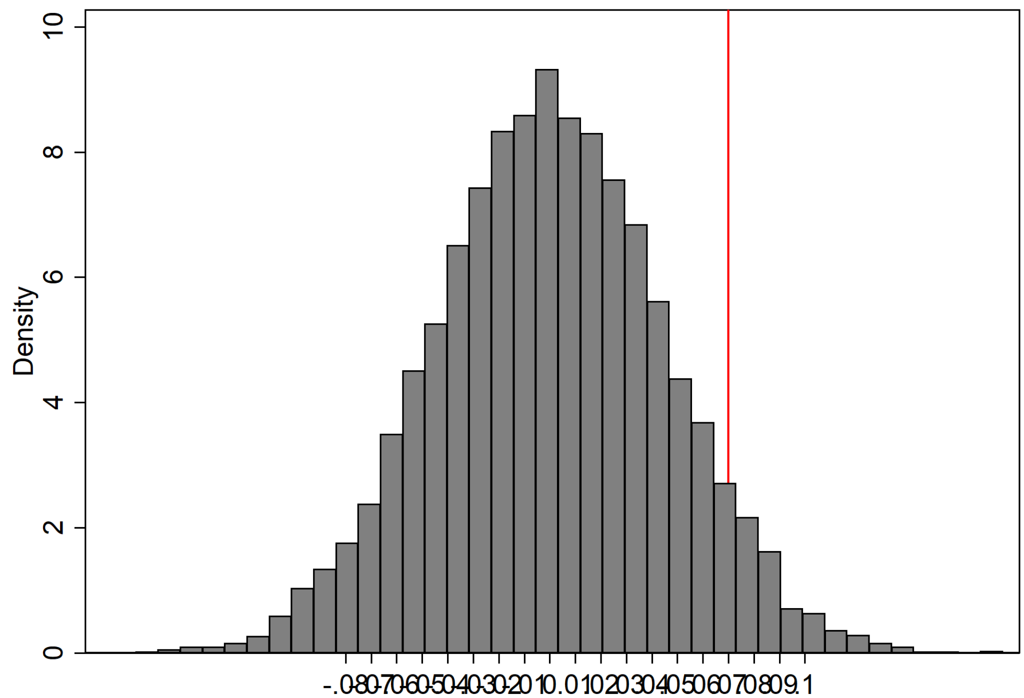


PANEL B: Villages



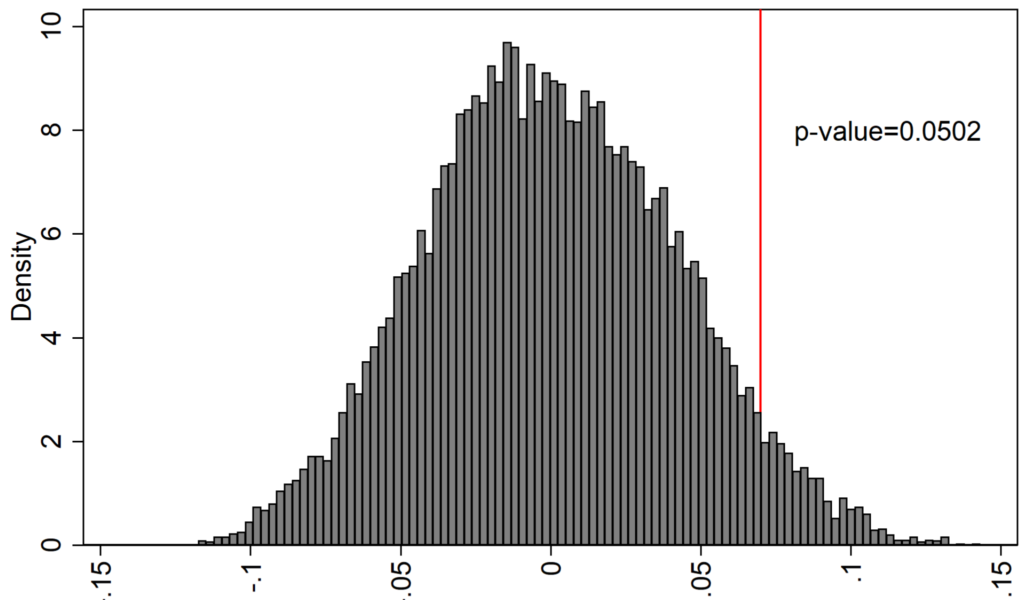
Notes: This figure plots the estimated coefficients on gold mine endowment, interacted with the world price of coltan, from specification 1 using all possible time intervals. Intervals indicate 95% confidence intervals. The size of the symbol on the coefficient estimate is proportional to the sample size used for that particular estimation, which depends on the start and end years for that particular regression. Panel A presents the mine-level results, collapsed at the level of a municipality-year. Panel B presents the support village-level results.

Figure F.6: Randomization inference, results from 20,000 simulated mine coltan endowments



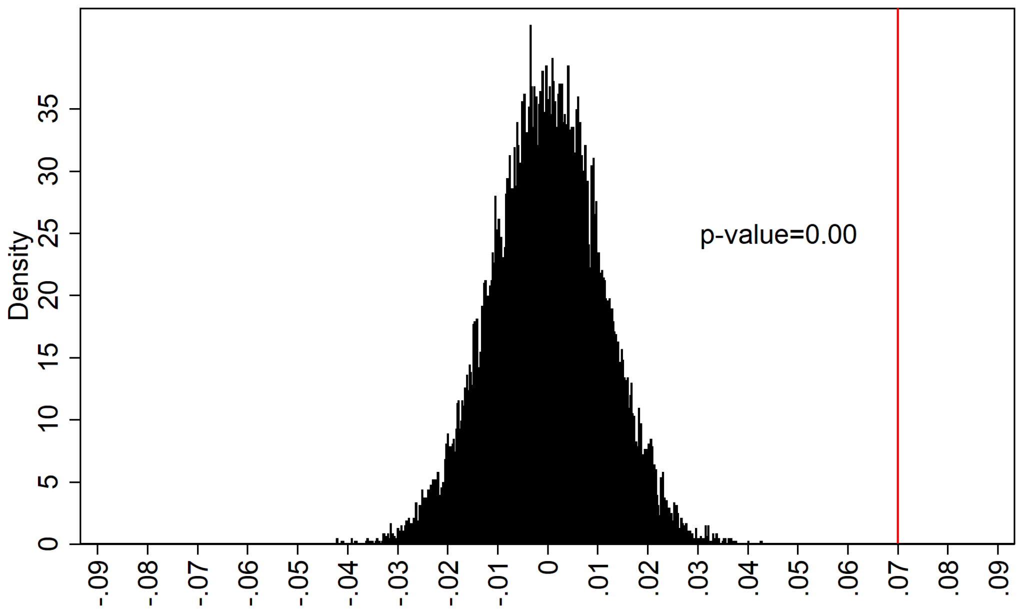
Notes: The figure presents the distribution of coefficients on the main coltan interaction estimated using simulated mine coltan endowments multiple times. To derive the p-value, I compute the mass of coefficients derived from the simulated endowments whose value is larger than the value estimated using the real endowments.

Figure F.7: Randomization inference, results from 20,000 simulated reassigned prices



Notes: The figure presents the distribution of coefficients on the main coltan interaction estimated using simulated prices, drawn multiple times from values of their observed distribution. To derive the p-value, I compute the mass of coefficients derived from the simulated prices whose value is larger than the actual coefficient.

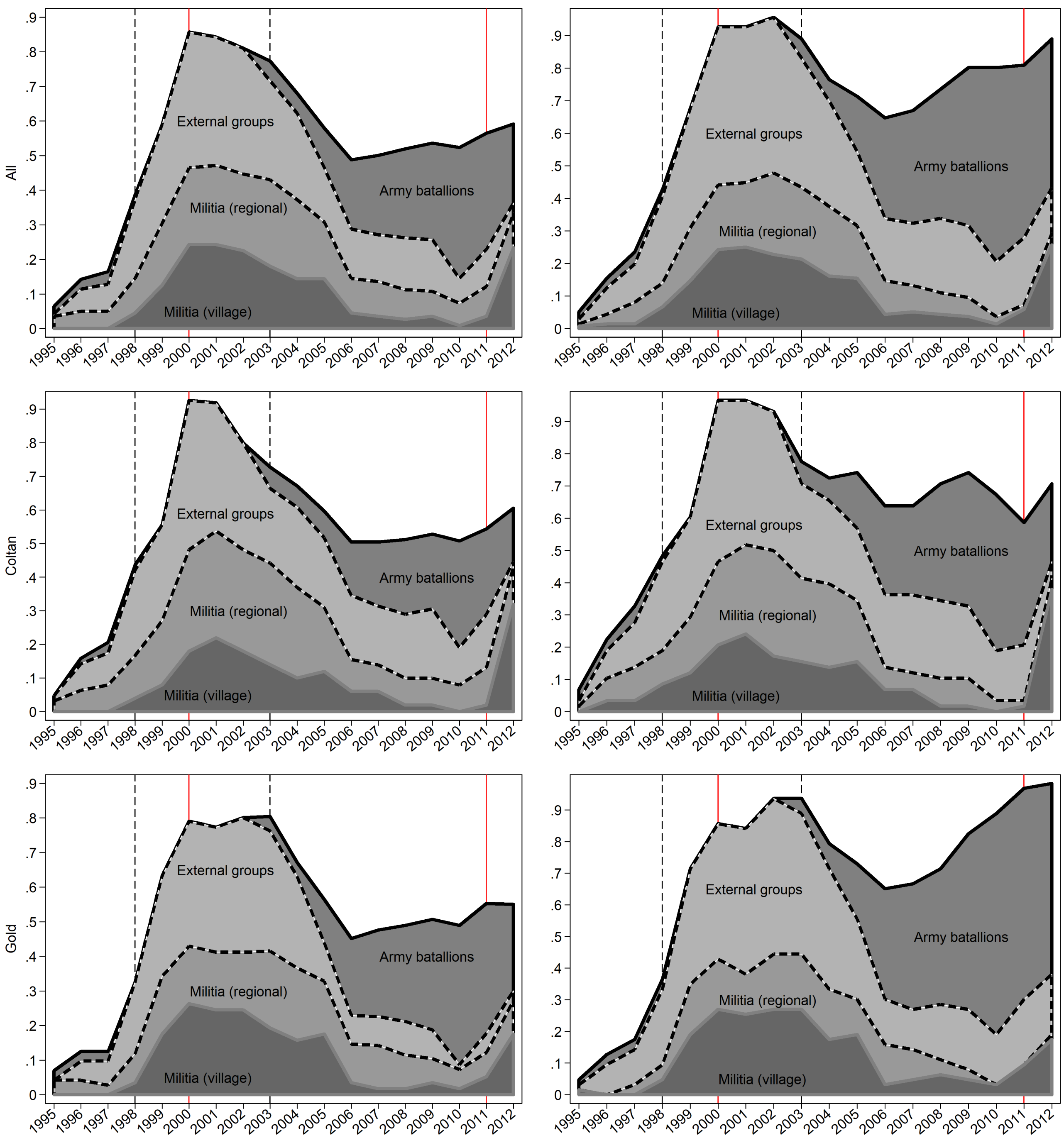
Figure F.8: Randomization inference, results from 20,000 price draws from a uniform



Notes: The figure presents the distribution of coefficients estimated using the simulated prices taken from a uniform distribution. To derive the p-value, I compute the mass of coefficients derived from the simulated endowments whose value is larger than the value estimated using the real endowments.

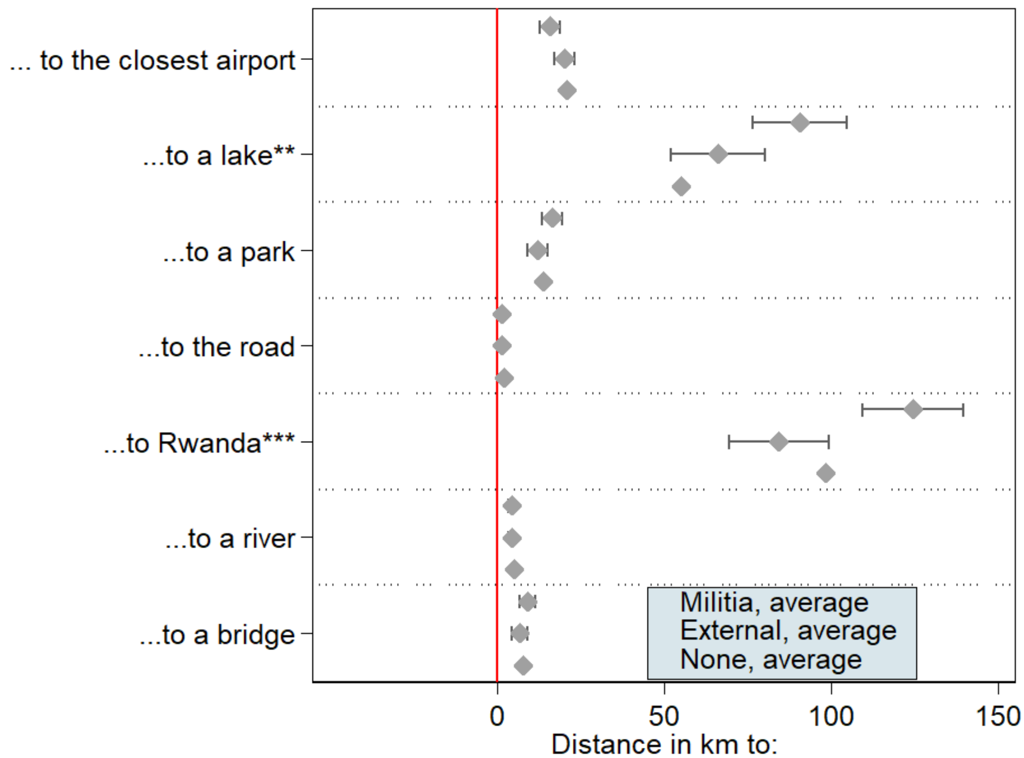
Figure F.9: Decomposition of armed actors by type

PANEL A: mines (n=411) **PANEL B:** support village (n=239)



Notes: This figure presents the composition of armed actors that are stationary bandits in any given location. Panel A (left) shows the mine level data, and Panel B (right) shows the support village level data. Rows 1, 2, and 3 respectively show the results for all locations, coltan locations, and gold locations. A mine is coded as coltan if it is endowed with coltan, and similarly for gold. A mine is coded as other if it has neither gold nor coltan. A support village is coded as coltan if its municipality has at least one coltan mining site, and similarly for gold. The left, gray, dashed vertical line indicates the start of the Second Congo war, and the right, gray, dashed vertical line indicates the date of the Sun City peace agreement. The solid, red, vertical lines indicate respectively the first, large, coltan price shock, and the second, smaller but more persistent, coltan price shock. Integration of armed groups into the FARD failed to change the pre-existing structures of command of the armed groups—many of which later mutinied—and new armed groups emerged, such as the multiple Raia Mutomboki factions, various Mayi-Mayi groups, the CNDP, the M23 and other groups (see Stearns et al. (2013)).

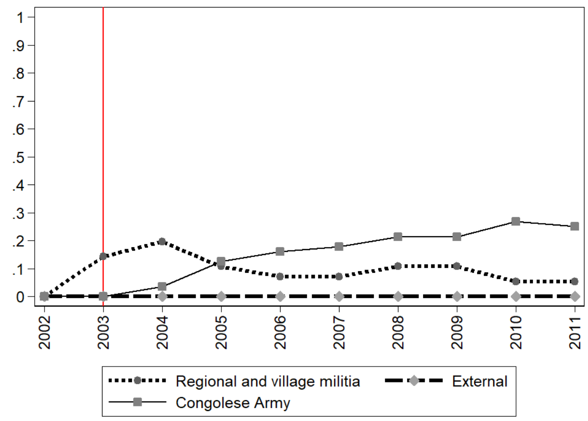
Figure F.10: Essential functions of a state and household welfare, instrumental variable approach—Balance test across types of municipalities



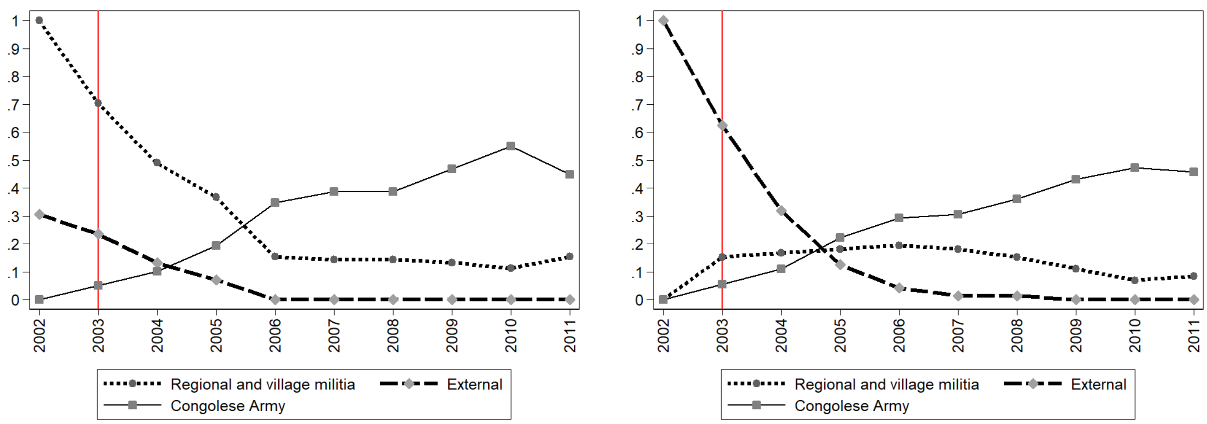
Notes: This figure presents the balance test for estimating the effect of different stationary bandits on welfare. I use all geographical data in Référentiel Géographique Commun (2010), and compute the distance to the shortest physical attribute for each support village, for each of the following attributes: local airport, a lake, a park, a road, Rwanda, a river, a bridge. Each category presents three outcomes, respectively from top to bottom: distance for villages which had a stationary bandit from a (regional or village) militia in 2002, distance for villages which had an external armed actor in 2002, and distance for villages which had no stationary bandit in 2002. All 239 support villages were included to construct this figure. Confidence intervals represent 95% confidence interval of independent two-sided hypothesis tests of whether the means are identical to the baseline. One, two, and three asterisks respectively indicate 1%, 5% and 10% significance level with Bonferroni's adjustment for multiple hypotheses testing. The lakes are respectively on the Ugandan/Rwandan border, and thus distance to a lake is strongly correlated to distance to Rwanda and Uganda (and so to Goma and Bukavu, not included, the border towns). Thus the three measures capture a similar underlying pattern.

Figure F.11: Essential functions of a state and household welfare, instrumental variable approach—First stage

Panel A: Control. Villages that had no stationary bandit in 2002

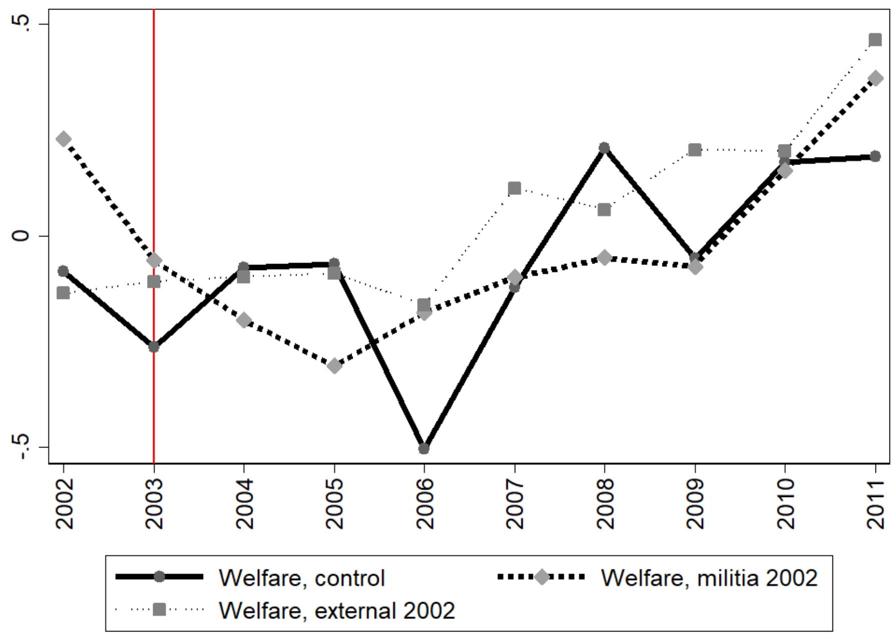


Panel B: Militia and external armed actors (RCD) in 2002 samples



Notes: This figure graphically presents the first stage for the IV specification that estimates the welfare effect on households. Panel A presents the composition of stationary bandits between 2002 and 2011 for support villages which did not have any stationary bandit in 2002. Panel B presents the sample for two groups of support villages. The right side shows support villages which had a stationary bandit from a (regional or village) militia in 2002. The identification strategy to estimate the effect of a stationary bandit from a (village or regional) militia on welfare is to compare the change in welfare outcomes in villages that had a stationary bandit in 2002 arising from a militia, to villages that did not have any stationary bandit in 2002. The right side shows villages which had a stationary bandit from an external armed actor in 2002. The identification strategy to estimate the effect of a stationary bandit from an external armed group on welfare is to compare the change in welfare outcomes in support villages that had a stationary bandit in 2002 arising from an external armed group, to support villages that did not have any stationary bandit in 2002.

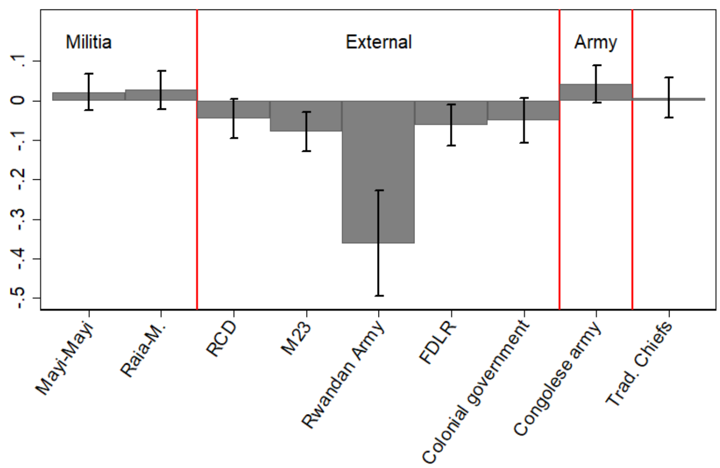
Figure F.12: Essential functions of a state and household welfare, instrumental variable approach—Reduced form



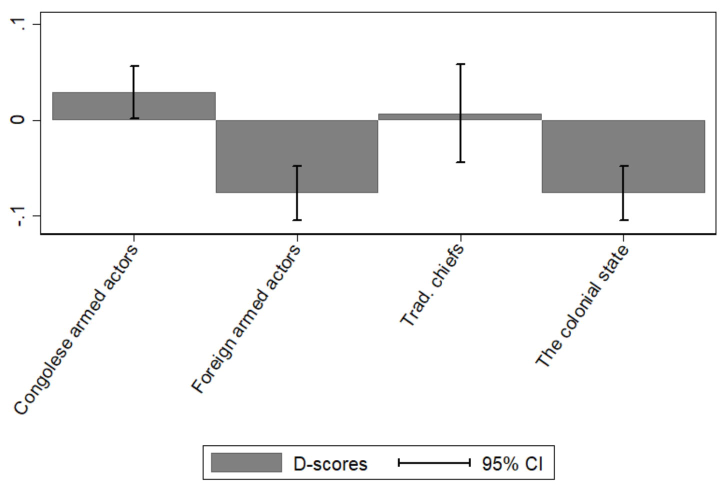
Notes: This figure graphically presents the reduced form for the IV specification that estimates the welfare effect on households. The y-axes represents the index for household welfare. The solid line plots the index for household welfare over time for support villages which did not have a stationary bandit in 2002. The thick dotted line plots the index for household welfare for support villages which had a stationary bandit in 2002 that was affiliated to a (village or regional) militia. The thin dotted line plots the wealth index for support villages which had an external stationary bandit in 2002. The index for household welfare is higher in support villages with a stationary bandit militia than any other support village. When stationary bandits affiliated to a (village or regional) militia depart after 2002, wealth in the support villages they controlled in 2002 converges to the rest of support villages. The welfare index is constructed using principal component analysis for marriages (collected at the level of the support village*year), immigration (collected at the level of the support village year), and household assets (collected at the level of the household). For household assets, to exclude compositional effects, I restrict the sample to households who were settled in the support village prior to 2000. I also collapse the household level data at the level of the support village to reduce concerns related to within-support village*year intra-cluster correlation.

Figure F.13: Do households like stationary bandits? Implicit association bias

Panel A: By regional origin

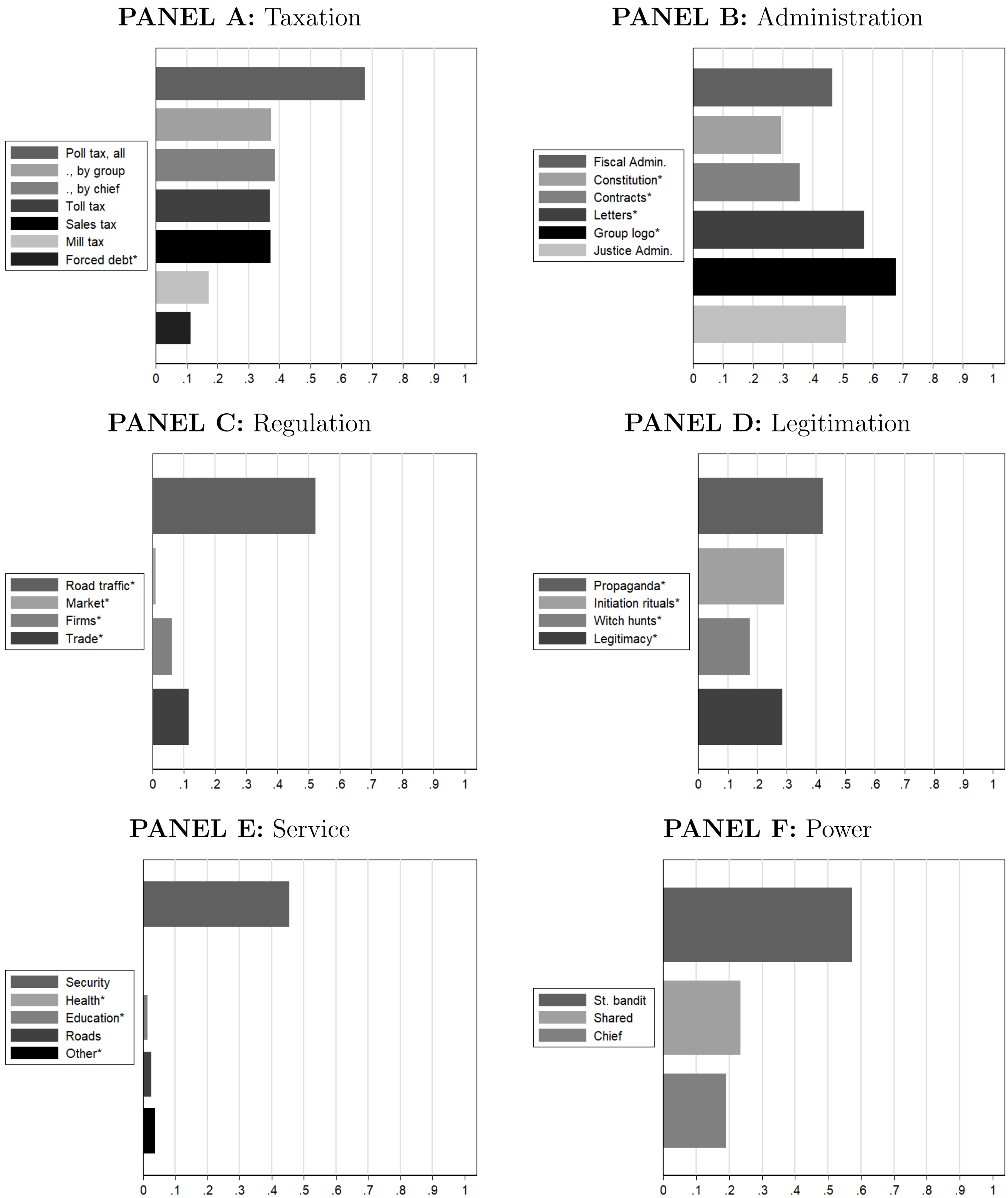


Panel B: By national origin - Congolese armed actors vs. “foreign” armed actors



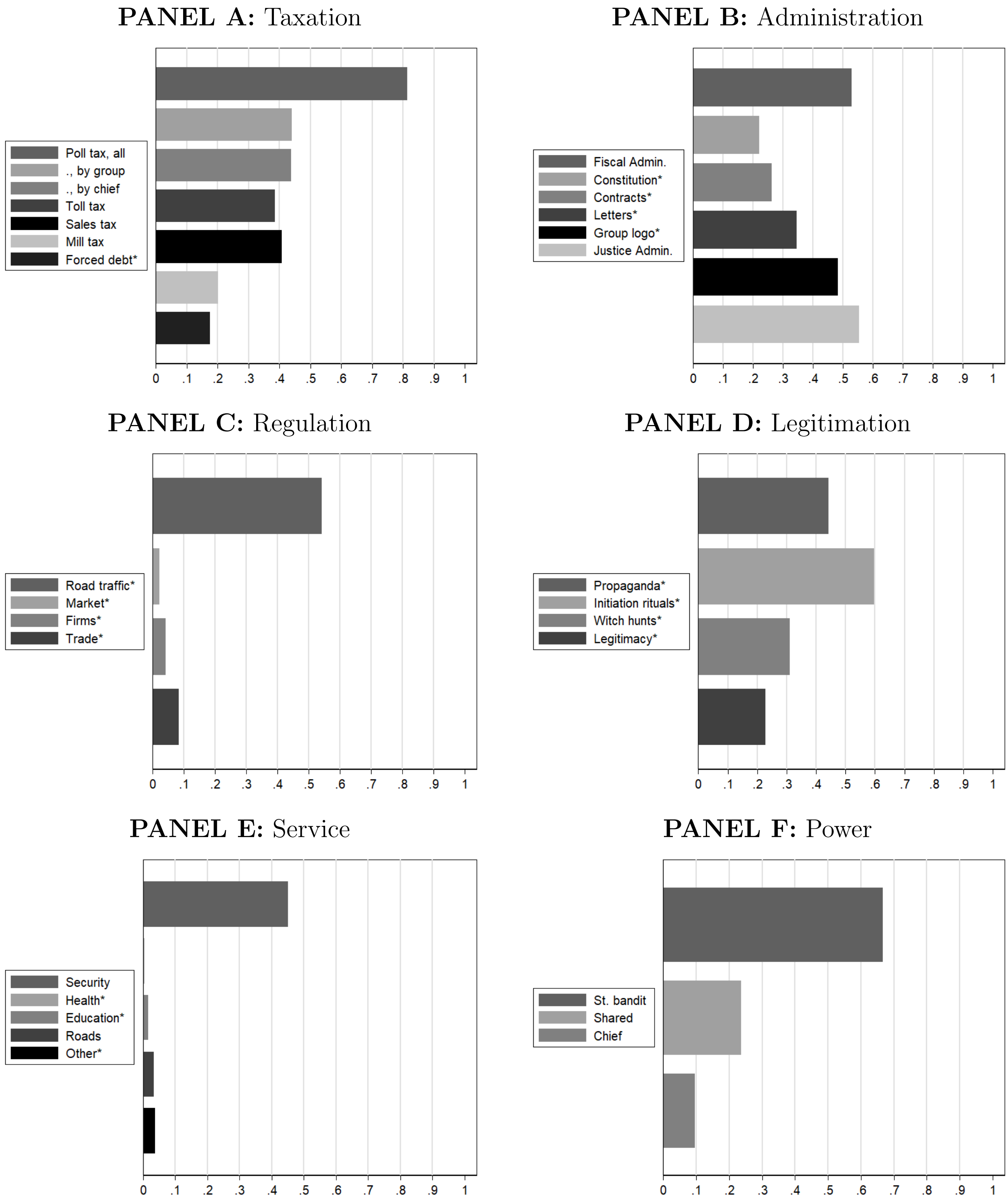
Notes: This figure presents the results from implicit association tests administered in Nord Kivu, by type of armed actor organization. The y axes show standardized mean indexes (mean zero and standard deviation of one) of the difference between IAT response time when the cue of interest is under a negative prime, and a positive prime. Panel A presents the results disaggregated among all commonly known armed actor organizations. Panel B presents the results aggregated into Congolese armed actors—Congolese (village and regional) militia and Congolese army (FARDC)—and external armed organizations (RCD, M23, Rwandan army, FDLR). It also includes the result for the colonial state as a benchmark for external armed organizations.

Figure F.14: What do stationary bandits do to intensify the essential functions?



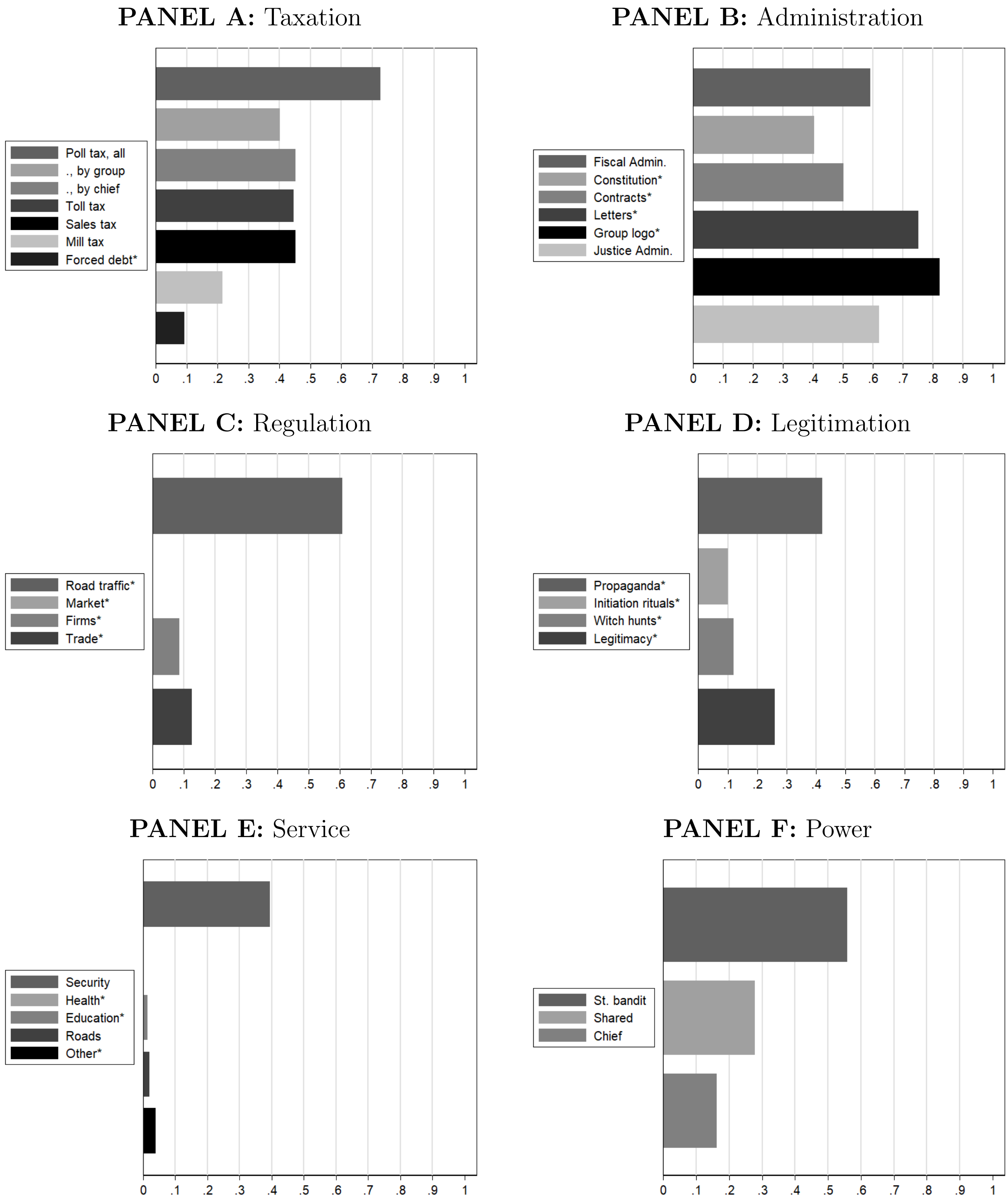
Notes: This figure breaks down the functions that stationary bandits have in the support villages they govern. There are 3,818 village*year observations. Panels A, B, C, D, E, and F show respectively the following 6 functions: fiscal sophistication (extraction), administration, economic regulation, legitimation, public service, and political power. The values indicate the proportion of village*year observations where a bandit is stationary in which each of the outcomes was recorded, which can vary within stationary bandit episode. The column "seen as legitimate" is the average household-level response, extracted in household interviews about each corresponding stationary bandit episode in the village as the answer to the following question: "Did you consider that the stationary bandit was legitimate in your view?" The intensive margin analysis uses the data on taxes raised, fiscal administration, and justice administration. "*" marks outcomes for which the data were only collected in Nord Kivu.

Figure F.15: What do stationary bandits do to intensify the essential functions? Militia



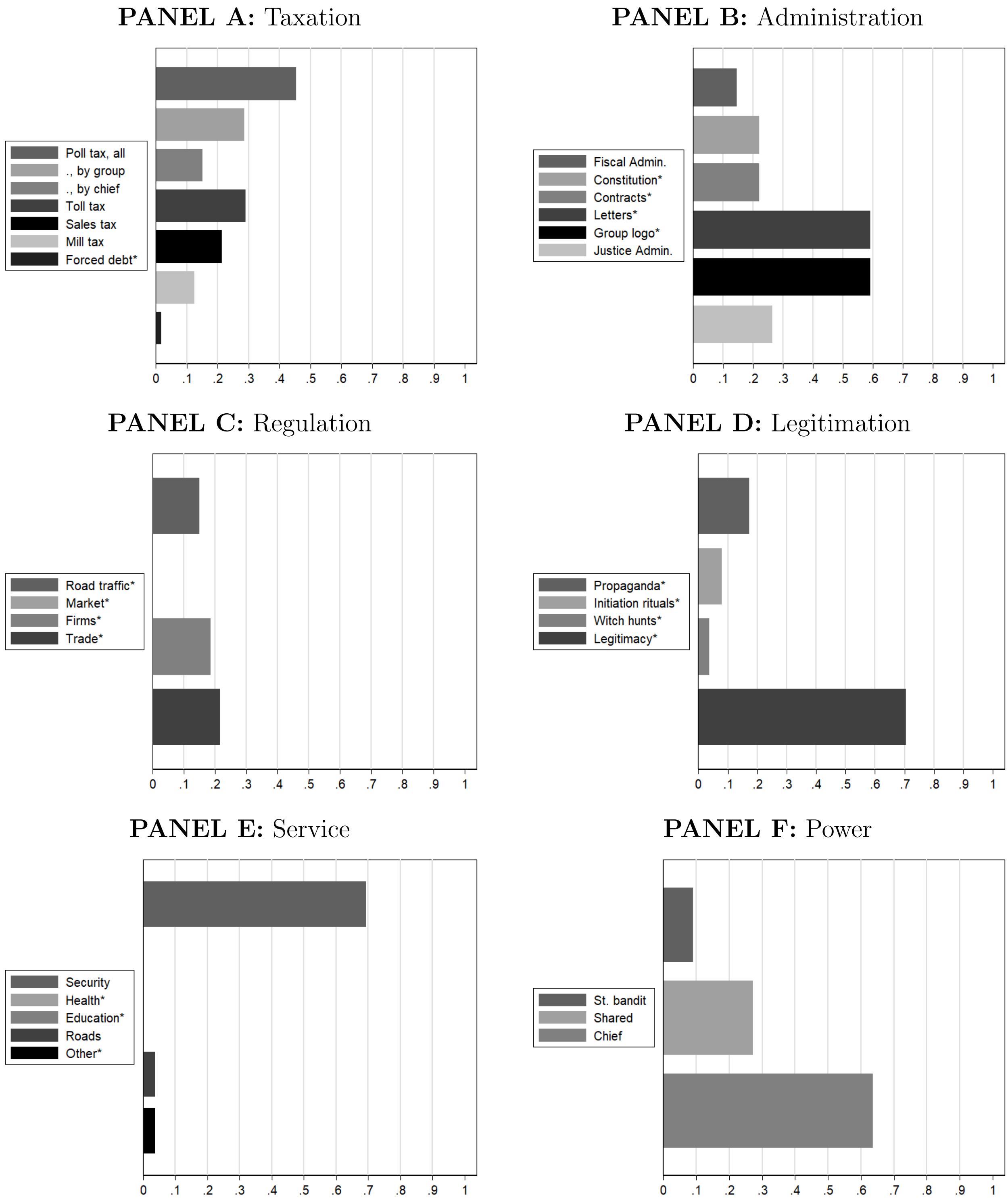
Notes: This figure breaks down the functions that stationary bandits that are affiliated to a (regional or village) militia have in the support villages they govern. There are 3,818 village*year observations. Panels A, B, C, D, E, and F show respectively the following 6 functions: fiscal sophistication (extraction), administration, economic regulation, legitimation, public service, and political power. The column "seen as legitimate" is the average household-level response, extracted in household interviews about each corresponding stationary bandit episode in the village as the answer to the following question: "Did you consider that the stationary bandit was legitimate in your view?" The values indicate the proportion of village*year observations where a bandit is stationary in which each of the outcomes was recorded. The outcomes can vary from year to year within stationary bandit episode. The intensive margin analysis uses the data on taxes raised, fiscal administration, and justice administration. "*" marks outcomes for which the data were only collected in Nord Kivu.

Figure F.16: What do stationary bandits do to intensify the essential functions? External



Notes: This figure breaks down the functions that stationary bandits that are affiliated to an external armed organization have in the support villages they govern. There are 3,818 village*year observations. Panels A, B, C, D, E, and F show respectively the following 6 functions: fiscal sophistication (extraction), administration, economic regulation, legitimation, public service, and political power. The column "seen as legitimate" is the average household-level response, extracted in household interviews about each corresponding stationary bandit episode in the village as the answer to the following question: "Did you consider that the stationary bandit was legitimate in your view?" The values indicate the proportion of village*year observations where a bandit is stationary in which each of the outcomes was recorded. The outcomes can vary from year to year within stationary bandit episode. The intensive margin analysis uses the data on taxes raised, fiscal administration, and justice administration. "*" marks outcomes for which the data were only collected in Nord Kivu.

Figure F.17: What do stationary bandits do to intensify the essential functions? Congolese army



Notes: This figure breaks down the functions that stationary bandits affiliated to the Congolese army (FARDC) have in the support villages they govern. There are 3,818 village*year observations. Panels A, B, C, D, E, and F show respectively the following 6 functions: fiscal sophistication (extraction), administration, economic regulation, legitimation, public service, and political power. The column "seen as legitimate" is the average household-level response, extracted in household interviews about each corresponding stationary bandit episode in the village as the answer to the following question: "Did you consider that the stationary bandit was legitimate in your view?" The values indicate the proportion of village*year observations where a bandit is stationary in which each of the outcomes was recorded. The outcomes can vary from year to year within stationary bandit episode. The intensive margin analysis uses the data on taxes raised, fiscal administration, and justice administration. "*" marks outcomes for which the data were only collected in Nord Kivu.

Figure F.18: Official authorization of the project

République Démocratique du Congo

PROVINCE DU SUD-KIVU

Ministère Provincial de l'Intérieur, de la Décentralisation de la Sécurité, et de la Fonction Publique

Le Ministre

Bukavu, le 13/09/2012

N/Réf. : N° CAB/MININTERDESEC-FP/314/TD/2012

Transmis copie pour information à :

- Son Excellence Monsieur le Gouverneur de la Province du Sud-Kivu ;
- Monsieur le Secrétaire Exécutif du Gouvernement Provincial ;
- Monsieur le Chef de Division Provinciale de l'Intérieur, de la Décentralisation et de la Sécurité ;
- Monsieur Raul Sanchez de la Sierra ;
- [redacted] ;

Objet : Autorisation d'effectuer des recherches

A Messieurs les Administrateurs des Territoires de Kalehe et de Mwenga

Messieurs les Administrateurs,

Par la présente, je vous informe que j'ai reçu Monsieur Raul SANCHEZ de la Sierra, MPhil de la Columbia University et Monsieur [redacted], venus me parler des études que leurs institutions souhaitent réaliser à travers la Province (Territoire) dans le cadre de leurs thèses sur l' « Histoire économique du Kivu rural ».

Ils ont une équipe d'enquêteurs qui les aident, notamment :

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Qui sont autorisés à prendre contact avec vous dans le cadre décrit ci-haut.

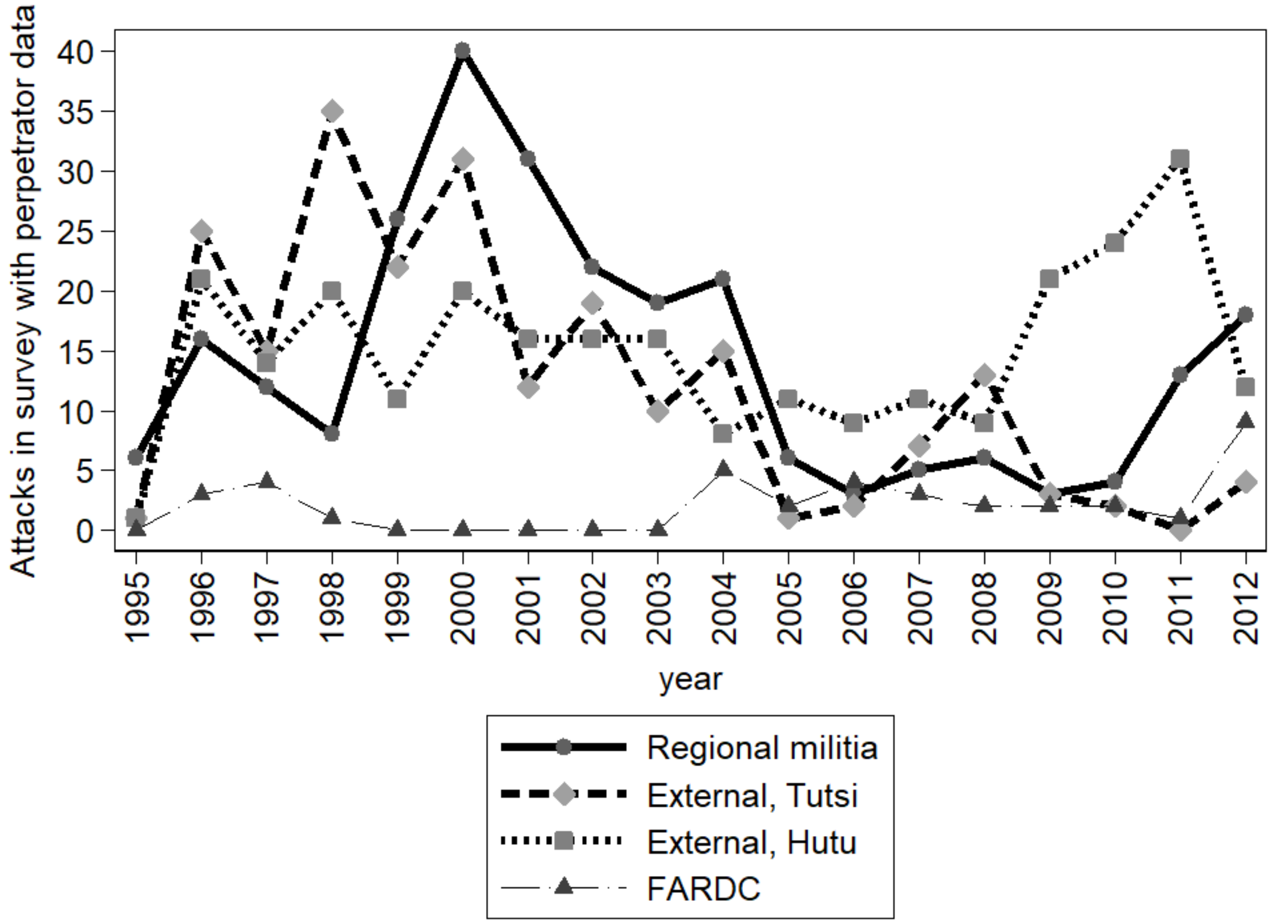
NB : Prière les accompagner par nos services techniques pour se rassurer que le comportement est conforme à leur engagement.

Sentiments civiques et patriotiques.

Me Etienne BABUNGA MUHIRWA

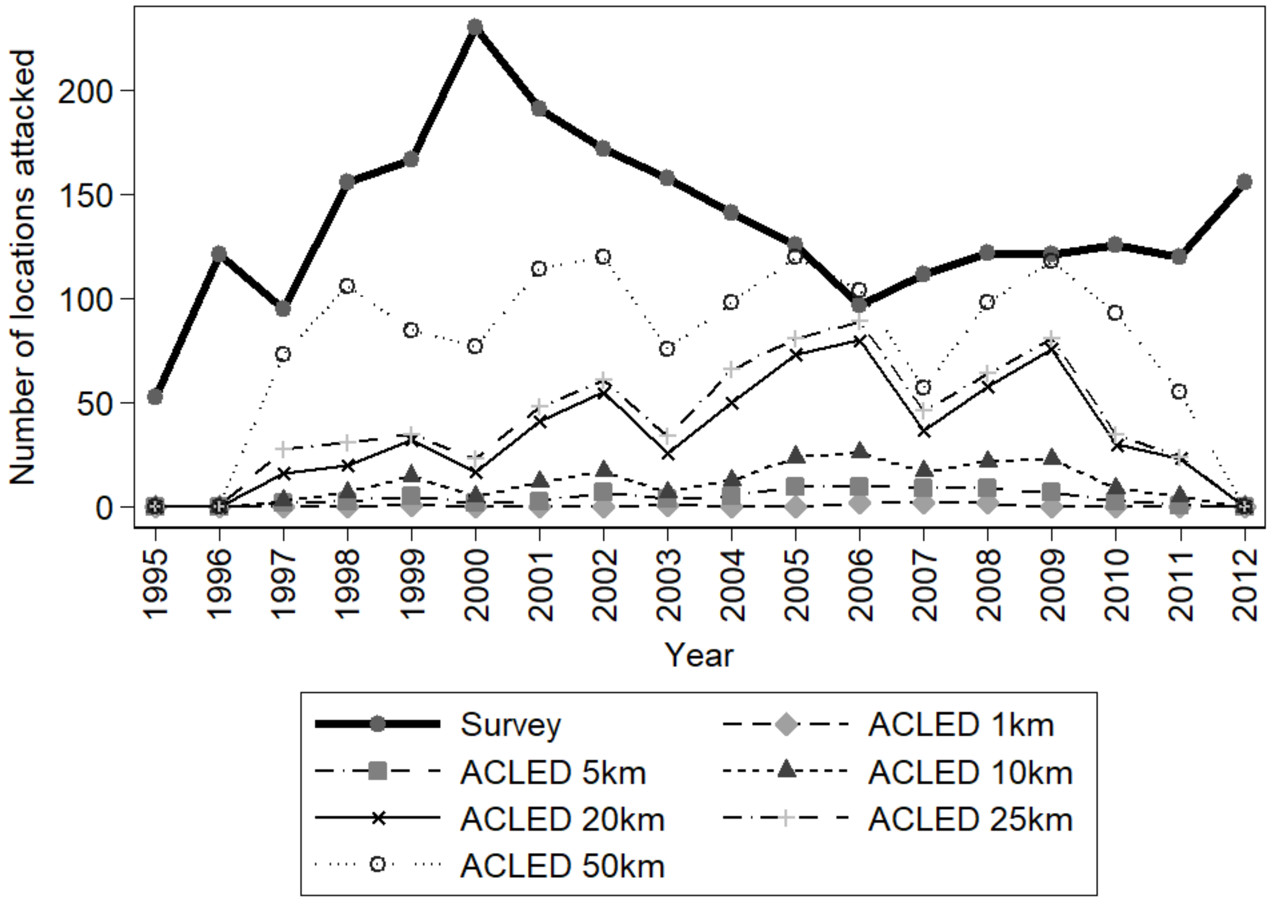
Notes: Official authorization for the project.

Figure F.19: Events recalled in detail, benchmarked to known historical rebellions



Notes: This figure plots the number of attacks on the sample villages by different armed organization identified in the survey for each year and uses well known dates for known historical rebellions as a benchmark. The left axis indicates the number of attacks recorded in the sample by armed actors of a given armed organization, and the horizontal axis indicates the year. The dates of the attacks recorded from the survey coincide exactly with well known historical rebellions, which are marked by the vertical lines. 1996 marks the period of the AFDL rebellion as it is known from the historical record; 1998 and 2003 bound the Second Congo War; 2008 is the year of the CNDP offensive, 2009 marks the Kimia II military intervention, which resulted in massive pillage operations by the FDLR (external Hutu) to acquire resources as their financial base was being disrupted, and 2011 indicates the year of the emergence of the Raia Mutomboki, a large regional militia, as known from the historical record. While the number of recorded attacks is larger in the survey, the source used in this figure is the attacks module, which gathers the identity o the perpetrator for the attacks villagers could remember.

Figure F.20: Classical measurement error due to recall? Survey and ACLED violent events



Notes: This figure plots the number of sample municipalities that are attacked, as reported by the survey and by ACLED. The solid line represents the total number of attacks recorded in the survey and the dashed lines represent the number of attacks recorded from ACLED, for different perimeters in the neighborhood of the survey support villages. To assign battles recorded by ACLED to the survey support villages, I computed the number of geo-located ACLED battles that were located within a given perimeter of the survey support village. The dashed lines report the results using the number of events of ACLED near the village using circles of radius 10km, 5 km, and 2 km. The solid line, obtained with data from this survey, matches well-known phases of the Congo Conflict. The number of attacks rises in 1998 drastically, with the beginning of the Second Congo War, and in 2000 during the coltan shock. Attacks then decrease with the post-conflict period, and rise again in 2009/2010. This last rise is the rise in attacks by the FDLR in response to the Kimia II military operation by the FARDC (see Sánchez de la Sierra (2018)). In contrast to the survey data, the geo-referenced ACLED dataset does not capture these patterns, especially for the First and Second Congo Wars. This provides additional confidence in the attacks data from the survey and suggests the ACLED data may not be suitable for geo-located analyses during the Congo wars.

Table F.1: Summary statistics

	Sample size	Coltan only	Gold only	WMW p-value	Source Source
Mining sites					
Stationary bandit (dummy)	2608	0.49	0.37	0.00***	Survey
Customs taxation on mining output, by armed actors (dummy)	924	0.23	0.13	0.00***	Survey
Daily working permit, by armed actors (dummy)	910	0.40	0.54	0.00***	
Support village					
Stationary bandit (dummy)	2448	0.58	0.58	0.00	Survey
Poll tax, per head, by armed actors (dummy)	1416	0.73	0.68	0.03**	Survey
Food sales tax at village market, by armed actors (dummy)	1413	0.27	0.38	0.00***	Survey
Toll fees on transit in/out of village, by armed actors(dummy)	1416	0.41	0.32	0.00***	Survey
Mill tax on agricultural mill activity, by armed actors (dummy)	1416	0.13	0.13	0.59	Survey
Security service on village, by armed actors (dummy)	1416	0.46	0.49	0.14	Survey
Justice administration of village, by armed actors (dummy)	1416	0.43	0.51	0.00***	Survey
Fiscal administration of village, by armed actors (dummy)	1416	0.38	0.45	0.00***	Survey
Accessible by car (dummy)	2177	0.18	0.15	0.21	Survey
Accessible by motorbike (dummy)	2177	0.32	0.31	0.91	Survey
Accessible by phone (dummy)	2178	0.11	0.13	0.05**	Survey
Distance to Rwanda (km)	2448	104.80	130.80	0.00***	Survey and RGC
Distance to the closest river (km)	2448	4.64	3.62	0.00***	Survey and RGC
Distance to the closest bridge (km)	2448	12.32	5.26	0.00***	Survey and RGC
Distance to the closest airport (km)	2448	18.90	15.86	0.00***	Survey and RGC

Notes: *** p<0.01, ** p<0.05, * p<0.1. This table presents the summary statistics of the main variables during the years of this study (1996 through 2013). The first column presents the sample size, the second column presents the proportion for coltan mines (or support villages endowed with coltan mines, when examining support village outcomes), the third column presents the sample size, the second column presents the proportion for gold mines (or support villages endowed with coltan mines, when examining support village outcomes), the fourth column presents the p-value of the null hypothesis that the difference between the proportion in coltan locations and the proportion in gold locations are identical (Wilcoxon-Mann-Whitney test, henceforth WMN). The last column presents the source. Sources: data from this survey and Référentiel Géographique Commun (2010). Coltan villages are closer to the eastern border (hence to natural reserves, the lake, Rwanda), and are further from rivers than gold support villages. The empirical strategy in this study paper to estimate the effect of the coltan price shock and the effect of the gold price shock exploits changes to mineral price shocks over time and changes in village outcomes over time. Thus, it is unaffected by constant observed and unobserved heterogeneity, such as proximity to the eastern border.

Table F.2: Effect of price shocks on whether violent attacks take place at the municipality

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Coltan(j) X pc(t)	0.20***	0.21***	0.14**	0.24***	0.11**	0.27***	0.23***	0.06	0.22***	0.20***	0.20***		0.26***
	(0.06)	(0.07)	(0.07)	(0.06)	(0.05)	(0.07)	(0.09)	(0.08)	(0.07)	(0.05)	(0.05)		(0.08)
Gold(j) X pg(t)	-0.06	-0.29**	-0.10	-0.14*	-0.04	-0.40***	-0.07	-0.06	-0.03	-0.06	-0.06		-0.21**
	(0.06)	(0.13)	(0.06)	(0.07)	(0.06)	(0.15)	(0.06)	(0.06)	(0.07)	(0.04)	(0.07)		(0.08)
Coltan(j) X pc(t+1)				-0.06									
				(0.05)									
Coltan(j) X pc(t-1)				0.08									
				(0.07)									
C(j) X pc(t) X D(a)(j)							-0.05						
							(0.11)						
pc(t) X D(a)(j)							-0.11**						
							(0.05)						
C(j) X pc(t) X D(r)(j)								0.24**					
								(0.11)					
pc(t) X D(r)(j)								-0.01					
								(0.05)					
Coltan(j) X local pc(t)												0.24***	
												(0.05)	
Observations	4,158	4,158	4,158	3,696	3,927	3,927	4,158	4,158	3,456	4,158	4,158	4,158	4,158
R-squared	0.44	0.44	0.44	0.45			0.44	0.44	0.43	0.44	0.44		0.44
Mineral time trends	NO	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
Region*Year FE	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Arellano-Bond	NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO	NO
Weights	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO
Cluster	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	R*Y	YES	YES
Model	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	OLS
Number of clusters					231	231						231	

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results of robustness checks on specification 1, using a dummy for whether violent attacks take place at the production economy (results using the support village, or the entire municipality, are the same). Column (1) implements specification 1. Column (2) adds mineral time trends. Column (3) adds region*year fixed effects. Column (4) adds leads and lags of the regressor. Column (5) implements Arellano-Bond GMM estimation. Column (6) implements Arellano-Bond GMM estimation with mineral time trends. Column (7) includes the interaction with the dummy indicating distance to local airports, $C_j\, p^{US}_{c,t} D^a_j$, as well as the corresponding interaction term $p^{US}_{c,t} D^a_j$. Column (8) includes in addition the analogous interactions for the distance to the road, $C_j\, p^{US}_{c,t} D^r_j$ and $p^{US}_{c,t} D^r_j$. In Column (9), I implement a weighted regression using working memory scores as weights. Column (10) replicates the main specification, with no clustering the standard errors. In column (11) standard errors are clustered at the region*year level. Column (12) instruments the local price of coltan with its world price. Column (13) replaces the time invariant coltan (gold) endowment dummy with an indicator of past coltan (gold) output.

Table F.3: Persistence — stationary bandits

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coltan(j) X pc(t)	0.07**	0.04*	0.03	0.03	0.06***	0.05***	0.06**
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Coltan(j) X pc(t-1)		0.05**	0.03*	0.03	0.02*	0.02*	
		(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	
Coltan(j) X pc(t-2)			0.08***	0.07**	0.04**	0.04**	
			(0.03)	(0.03)	(0.02)	(0.02)	
Coltan(j) X pc(t-3)				0.03	-0.02	0.03	
				(0.03)	(0.02)	(0.02)	
Stationary bandit (t-1)					0.28***	0.27***	0.50***
					(0.03)	(0.03)	(0.14)
Coltan(j) X local pc(t)						0.11***	
						(0.02)	
Observations	3,991	3,770	3,549	3,107	3,325	3,325	3,767
R-squared	0.60	0.61	0.63	0.67			
Number of clusters					222	222	222

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table shows the estimates from a linear probability model with municipality and year fixed effects, regressing a dummy that indicates the presence of a stationary bandit on the lagged values of $C_j \;\; p^{US}_{c,t}$. Columns (1) to (4) replicate the baseline specification, but include the lags. The coefficient on the lags of $C_j \;\; p^{US}_{c,t}$ suggests that the coltan price has persistent effect, despite that the variation is coming from a temporary price surge in 2000. Column (5) adds the lagged dependent variable as a regressor and implements Arellano-Bond GMM estimation. The coefficient on lagged stationary bandit on stationary bandit is large and significant. To rule out that continued local demand for coltan is accounting for the persistence of stationary bandits, column (6) includes, in addition, the average price of coltan paid by traders locally at the site level, collected in the survey. Even after including the local price, which is statistically significant, contemporaneous and lagged effects of the world price persist. Finally, column (7) implements a 2SLS panel regression of stationary bandit on its lag, where I instrument the first lag of stationary bandit with the first lag of $C_j \;\; p^{US}_{c,t}$ in order to account for the endogenous location of stationary bandits. All regressions include year fixed effects, municipality fixed effects, and standard errors are clustered at the level of the municipality. Data is collapsed at the municipality level.

Table F.4: Explaining the rise of taxation, stationary bandits, and protection—airports

VARIABLES	(1) **Attack Mine**	(2) **Customs Tax Mine**	(3) **Entry Fees Mine**	(4) **Stationary Bandit Mine**	(5) **Security Service Mine**	(6) **Extensive Index Mine**	(7) **Stationary Bandit Village**	(8) **Security Service Village**	(9) **Extensive Index Village**
Coltan(j) X pc(t)	0.23***	0.12***	0.05*	0.15***	0.12***	0.35***	0.14***	0.12***	0.32***
	(0.09)	(0.03)	(0.03)	(0.03)	(0.04)	(0.07)	(0.03)	(0.03)	(0.07)
C(j) X pc(t) X D(a)(j)	-0.05	-0.13***	-0.08**	-0.15***	-0.12***	-0.39***	-0.20***	-0.19***	-0.49***
	(0.11)	(0.04)	(0.04)	(0.05)	(0.04)	(0.10)	(0.05)	(0.04)	(0.10)
Gold(j) X pg(t)	-0.06	-0.06**	0.04	0.05	0.05	0.06	0.10**	0.15***	0.31***
	(0.07)	(0.03)	(0.03)	(0.05)	(0.05)	(0.09)	(0.04)	(0.05)	(0.09)
G(j) X pc(t) X D(a)(j)	-0.02	0.07**	0.01	-0.01	0.02	0.09	0.03	0.01	0.04
	(0.13)	(0.03)	(0.05)	(0.06)	(0.06)	(0.11)	(0.06)	(0.07)	(0.14)
Observations	4,158	4,046	4,052	3,991	4,032	3,903	4,302	4,302	4,302
R-squared	0.44	0.60	0.69	0.60	0.63	0.65	0.50	0.43	0.50

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1 using as dependent variables the extensive margin outcomes, with the inclusion of the distances to airports. All columns add the interaction of the main regressor, $Coltan(j)Xpc(t)$, with the constant municipality-level dummy indicating whether the municipality's shortest distance to an airport is above the sample median, $D(airport)(j)$. Columns (1) through (6) show the outcomes at the production site (mine), and columns (7) through (9) at the support village corresponding to the mine. Column (1) uses a dummy indicating whether an armed actor attacked the mine as dependent variable. Column (2) uses a dummy indicating whether an armed actor imposed customs taxation on mining output at the exit of the mine (enforced through a roadblock). Column (3) uses a dummy indicating whether an armed actor imposed an entry fee to work at the mine (enforced through a roadblock). Column (4) uses a dummy indicating whether an armed actor had established a monopoly of violence at the mine. Column (5) uses a dummy indicating whether an armed actor provided a security service at the mine. Column (6) uses the extensive margin index at the mine as dependent variable. The extensive margin index at the mine is constructed as the mean of customs taxation, entry fees, stationary bandit, and security service, normalized to mean zero and standard deviation of one. Column (7) uses instead a dummy indicating whether an armed actor had established a monopoly of violence at the support village corresponding to the mine. Column (8) uses a dummy indicating whether an armed actor provided a security service at the support village corresponding to the mine. Column (9) uses the extensive margin index at the support village as dependent variable. The extensive margin index at the support village is constructed as the mean of stationary bandit and security service at the village, normalized to mean zero and standard deviation of one. There are 239 municipalities in the sample, broken down into 239 support villages, and their corresponding 411 mining sites. The mine*year level data is collapsed at the municipality-year level. All columns include year and municipality level fixed effects. Standard errors are clustered at the level of the municipality to account for autocorrelation in the dependent variable, the mineral endowments (which are time invariant), and the mineral price.

Table F.5: Robustness checks—extensive margin index (mines)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Coltan(j) X pc(t)	0.16***	0.14**	0.15**	0.18***	0.08**	0.20***	0.36***	-0.03	0.21***	0.16***	0.16*		0.22**
	(0.06)	(0.06)	(0.07)	(0.05)	(0.03)	(0.07)	(0.07)	(0.09)	(0.06)	(0.04)	(0.09)		(0.09)
Gold(j) X pg(t)	0.10	-0.33**	0.14*	0.07	0.01	-0.01	0.10	0.11	0.16**	0.10***	0.10*		-0.03
	(0.07)	(0.14)	(0.08)	(0.08)	(0.03)	(0.14)	(0.07)	(0.07)	(0.08)	(0.04)	(0.05)		(0.09)
Coltan(j) X pc(t+1)				-0.12**									
				(0.06)									
Coltan(j) X pc(t-1)				0.21***									
				(0.05)									
C(j) X pc(t) X D(a)(j)							-0.40***						
							(0.10)						
pc(t) X D(a)(j)							-0.02						
							(0.05)						
C(j) X pc(t) X D(r)(j)								0.33***					
								(0.11)					
pc(t) X D(r)(j)								-0.08*					
								(0.05)					
Coltan(j) X local pc(t)												0.17***	
												(0.05)	
Observations	3,903	3,903	3,903	3,470	3,669	3,669	3,903	3,903	3,243	3,903	3,903	3,903	3,903
R-squared	0.65	0.65	0.66	0.67			0.65	0.65	0.65	0.65	0.65		0.65
Mineral time trends	NO	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
Region*Year FE	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Arellano-Bond	NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO	NO
Weights	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO
Cluster	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	R*Y	YES	YES
Model	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	OLS
Number of clusters					222	222						222	

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results of robustness checks on specification 1 on the mine-level data, using the extensive margin index as dependent variable. There are 239 municipalities in the sample, broken down into 239 support villages, and their corresponding 411 mining sites. The mine*year level data is collapsed at the municipality-year level. All columns include year and municipality level fixed effects. Column (1) implements specification 1. Column (2) adds mineral time trends. Column (3) adds region*year fixed effects. Column (4) adds leads and lags of the regressor. Column (5) implements Arellano-Bond GMM estimation. Column (6) implements Arellano-Bond GMM estimation with mineral time trends. Column (7) includes the interaction with the dummy indicating distance to local airports, $C_j \; p^{US}_{c,t} D^a_j$, as well as the corresponding interaction term $p^{US}_{c,t} D^a_j$. Column (8) includes in addition the analogous interactions for the distance to the road, $C_j \; p^{US}_{c,t} D^r_j$ and $p^{US}_{c,t} D^r_j$. In Column (9), I implement a weighted regression using working memory scores as weights. Column (10) replicates the main specification, with no clustering the standard errors. In column (11) standard errors are clustered at the region*year level. Column (12) instruments the local price of coltan with its US price. Column (13) replaces the time invariant coltan (gold) endowment dummy with an indicator of past coltan (gold) output.

Table F.6: Robustness checks — extensive margin index (support village)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Coltan(j) X pc(t)	0.07	0.07	0.02	0.06	0.08	0.08	0.33***	0.01	0.07	0.07*	0.07		0.10
	(0.05)	(0.05)	(0.06)	(0.04)	(0.05)	(0.05)	(0.07)	(0.08)	(0.06)	(0.04)	(0.06)		(0.06)
Gold(j) X pg(t)	0.33***	0.33***	0.26***	0.34***	0.04**	0.04**	0.33***	0.33***	0.30***	0.33***	0.33***		0.24***
	(0.08)	(0.08)	(0.09)	(0.08)	(0.02)	(0.02)	(0.08)	(0.08)	(0.08)	(0.04)	(0.06)		(0.05)
Coltan(j) X pc(t+1)				-0.03									
				(0.05)									
Coltan(j) X pc(t-1)				0.10**									
				(0.05)									
C(j) X pc(t) X D(a)(j)							-0.49***						
							(0.10)						
pc(t) X D(a)(j)							0.07						
							(0.05)						
C(j) X pc(t) X D(r)(j)								0.13					
								(0.11)					
pc(t) X D(r)(j)								-0.09*					
								(0.05)					
Coltan(j) X local pc(t)												0.64***	
												(0.08)	
Observations	4,302	4,302	4,302	4,266	4,063	4,063	4,302	4,302	3,600	4,302	4,302	4,302	4,302
R-squared	0.50	0.50	0.51	0.50			0.50	0.50	0.49	0.50	0.50		0.49
Mineral time trends	NO	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
Region*Year FE	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Arellano-Bond	NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO	NO
Weights	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO
Cluster	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	R*Y	YES	YES
Model	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	OLS
Number of groupreshapeid					239	239						239	

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results of robustness checks on specification 1 on the support village data, using the extensive margin index at the support village as dependent variable. There are 239 municipalities in the sample, broken down into 239 support villages, and their corresponding 411 mining sites. All columns include year and municipality level fixed effects. Column (1) implements specification 1. Column (2) adds mineral time trends. Column (3) adds region*year fixed effects. Column (4) adds leads and lags of the regressor. Column (5) implements Arellano-Bond GMM estimation. Column (6) implements Arellano-Bond GMM estimation with mineral time trends. Column (7) includes the interaction with the dummy indicating distance to local airports, $C_j \, p^{US}_{c,t} D^a_j$, as well as the corresponding interaction term $p^{US}_{c,t} D^a_j$. Column (8) includes in addition the analogous interactions for the distance to the road, $C_j \, p^{US}_{c,t} D^r_j$ and $p^{US}_{c,t} D^r_j$. In Column (9), I implement a weighted regression using working memory scores as weights. Column (10) replicates the main specification, with no clustering the standard errors. In column (11) standard errors are clustered at the region*year level. Column (12) instruments the local price of gold with its US price. Column (13) replaces the time invariant coltan (gold) endowment dummy with an indicator of past coltan (gold) output.

Table F.7: Who are the stationary bandits? Decomposition of the mineral price shock effect by stationary bandit type

PANEL A: Mines (n=411)

VARIABLES	(1) **Village militia**	(2) **Regional militia**	(3) **Congolese Army**	(4) **External Tutsi**	(5) **External Hutu**
Coltan(j) X pc(t)	0.01**	0.03***	0.01	0.01**	-0.00
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Gold(j) X pg(t)	-0.00	0.01	0.01	-0.00	-0.00
	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)
Observations	4,490	5,268	6,015	6,192	5,958
R-squared	0.29	0.44	0.34	0.37	0.38

PANEL B: Support village (n=239)

VARIABLES	(1) **Village militia**	(2) **Regional militia**	(3) **Congolese Army**	(4) **External Tutsi**	(5) **External Hutu**
Coltan(j) X pc(t)	0.02	0.01	0.00	0.03**	0.01
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Gold(j) X pg(t)	-0.03	-0.06*	0.19***	-0.04	0.01
	(0.03)	(0.03)	(0.04)	(0.03)	(0.02)
Observations	4,302	4,302	4,302	4,302	4,302
R-squared	0.30	0.26	0.49	0.47	0.39

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1, by type of stationary bandit. Panel A presents the results at the mines (not collapsed at the municipality*year level for identification of the main armed actor), and Panel B at the support villages. Columns (1) and (2) respectively use village militia and regional militia. Columns (3) to (5) decompose non-militia armed organizations into the Congolese army (FARDC), external armed actors of Tutsi ethnic group (or that represent the interests of Tutsi groups), and the same for armed groups of Hutu ethnicity (mostly the FDLR and Interahamwe). Village militia are stationary bandits that emerge in the municipality as a popular mobilization. Regional militia are popular mobilizations that emerge in the region, but not in the municipality. Regional militia include the many Mayi-Mayi factions—Janvier, Kaganga, Kasingie, Kifuafua, Padiri, Lafontaine, Lulwako, Mudohu, Katalayi, Mze, Nyakiliba, Sim, Samy, Surambaya—Raia Mutomboki (factions Eyadema/Kikuni, former Kifuafua, Jean Musumbu, Sisawa/Meshe/Ngandu), Nyatura, Batiri, Katuku, and Mbaire. External organizations are not from the area, most often "foreign" ethnic groups. External organizations include the Tutsi-dominated RCD, CNDP, AFDL, M23, and PARECO, the Hutu-dominated FDLR (including FDLR Tanganyika) and Interahamwe, as well as other groups, such as ADF-NALU. Panel A regressions include mining site and year fixed effects, and Panel B include support village and year fixed effects. All regressions include year fixed effects, municipality (or mine, for Panel A) fixed effects, and standard errors are clustered at the level of the municipality. The sample size examining the presence of village militia at the mines is smaller because the presence of village militia *at the mines* were only measured in Sud Kivu and because it is a rare occurrence.

Table F.8: Explaining the rise of taxation, stationary bandits, and protection—Excluding the Congolese army (FARDC)

VARIABLES	(1) **Attack Mine**	(2) **Customs Tax Mine**	(3) **Entry Fees Mine**	(4) **Stationary Bandit Mine**	(5) **Security Service Mine**	(6) **Extensive Index Mine**	(7) **Stationary Bandit Village**	(8) **Security Service Village**	(9) **Extensive Index Village**
Coltan(j) X pc(t)	0.09***	0.08***	0.00	0.08***	0.06**	0.19***	0.04	0.04*	0.10*
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.06)	(0.03)	(0.02)	(0.06)
Gold(j) X pg(t)	-0.02	-0.02	0.02	-0.01	-0.02	-0.02	-0.08**	-0.02	-0.13*
	(0.03)	(0.02)	(0.03)	(0.04)	(0.04)	(0.08)	(0.03)	(0.03)	(0.07)
Observations	4,158	3,783	3,795	3,728	3,769	3,646	4,302	4,302	4,302
R-squared	0.11	0.57	0.67	0.59	0.60	0.63	0.46	0.32	0.43

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1, excluding the FARDC from the analysis, and using as dependent variables the extensive margin outcomes. Columns (1) through (6) show the outcomes at the production site (mine), and columns (7) through (9) at the support village corresponding to the mine. Column (1) uses a dummy indicating whether an armed actor attacked the mine as dependent variable. Column (2) uses a dummy indicating whether an armed actor imposed customs taxation on mining output at the exit of the mine (enforced through a roadblock). Column (3) uses a dummy indicating whether an armed actor imposed an entry fee to work at the mine (enforced through a roadblock). Column (4) uses a dummy indicating whether an armed actor had established a monopoly of violence at the mine. Column (5) uses a dummy indicating whether an armed actor provided a security service at the mine. Column (6) uses the extensive margin index at the mine as dependent variable. The extensive margin index at the mine is constructed as the mean of customs taxation, entry fees, stationary bandit, and security service, normalized to mean zero and standard deviation of one. Column (7) uses instead a dummy indicating whether an armed actor had established a monopoly of violence at the support village corresponding to the mine. Column (8) uses a dummy indicating whether an armed actor provided a security service at the support village corresponding to the mine. Column (9) uses the extensive margin index at the support village as dependent variable. The extensive margin index at the support village is constructed as the mean of stationary bandit and security service at the village, normalized to mean zero and standard deviation of one. There are 239 municipalities in the sample, broken down into 239 support villages, and their corresponding 411 mining sites. The mine*year level data is collapsed at the municipality-year level. All columns include year and municipality level fixed effects. Standard errors are clustered at the level of the municipality to account for autocorrelation in the dependent variable, the mineral endowments (which are time invariant), and the mineral price. Table F.7 and Figure F.9 show the effect of the price shocks on the composition of stationary bandits. Table 1 presents the results including all armed actors. To compute attacks by non-FARDC actors, I use the attacks module. This module builds on a smaller number of events (those the respondents remembered in detail), but contains information about the perpetrators.

Table F.9: Explaining the rise of taxation, stationary bandits, and protection—Including only the Congolese army (FARDC)

VARIABLES	(1) **Attack Mine**	(2) **Customs Tax Mine**	(3) **Entry Fees Mine**	(4) **Stationary Bandit Mine**	(5) **Security Service Mine**	(6) **Extensive Index Mine**	(7) **Stationary Bandit Village**	(8) **Security Service Village**	(9) **Extensive Index Village**
Coltan(j) X pc(t)	0.01	-0.00	0.02	0.04**	0.04**	0.17**	0.00	-0.02	-0.02
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.08)	(0.02)	(0.02)	(0.05)
Gold(j) X pg(t)	0.01*	-0.02*	0.07***	0.13***	0.11***	0.48***	0.19***	0.17***	0.54***
	(0.01)	(0.01)	(0.02)	(0.04)	(0.03)	(0.14)	(0.04)	(0.04)	(0.10)
Observations	4,158	4,158	4,152	4,158	4,158	4,152	4,302	4,302	4,302
R-squared	0.07	0.42	0.34	0.39	0.36	0.37	0.49	0.46	0.49

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1, including only the FARDC in the analysis, and using as dependent variables the extensive margin outcomes. Columns (1) through (6) show the outcomes at the production site (mine), and columns (7) through (9) at the support village corresponding to the mine. Column (1) uses a dummy indicating whether an armed actor attacked the mine as dependent variable. Column (2) uses a dummy indicating whether an armed actor imposed customs taxation on mining output at the exit of the mine (enforced through a roadblock). Column (3) uses a dummy indicating whether an armed actor imposed an entry fee to work at the mine (enforced through a roadblock). Column (4) uses a dummy indicating whether an armed actor had established a monopoly of violence at the mine. Column (5) uses a dummy indicating whether an armed actor provided a security service at the mine. Column (6) uses the extensive margin index at the mine as dependent variable. The extensive margin index at the mine is constructed as the mean of customs taxation, entry fees, stationary bandit, and security service, normalized to mean zero and standard deviation of one. Column (7) uses instead a dummy indicating whether an armed actor had established a monopoly of violence at the support village corresponding to the mine. Column (8) uses a dummy indicating whether an armed actor provided a security service at the support village corresponding to the mine. Column (9) uses the extensive margin index at the support village as dependent variable. The extensive margin index at the support village is constructed as the mean of stationary bandit and security service at the village, normalized to mean zero and standard deviation of one. There are 239 municipalities in the sample, broken down into 239 support villages, and their corresponding 411 mining sites. The mine*year level data is collapsed at the municipality-year level. All columns include year and municipality level fixed effects. Standard errors are clustered at the level of the municipality to account for autocorrelation in the dependent variable, the mineral endowments (which are time invariant), and the mineral price. Table F.7 and Figure F.9 show the effect of the price shocks on the composition of stationary bandits. Table 1 presents the results including all armed actors. To compute attacks by the FARDC, I use the attacks module. This module builds on a smaller number of events (those the respondents remembered in detail), but contains information about the perpetrators. Including only the FARDC attacks (column 1), the gold price shock has a positive effect on attacks at the support village, which, consistent with the discussion in Section G.1, indicates that the strongest armed actor in the area targets the most profitable of the village/mine pairs in response to changes in their value (since gold output is difficult to tax, the FARDC targets the support villages).

Table F.10: Essential functions of a state and household welfare—Heterogeneous effect of the shocks, with controls

Panel A: Coltan price

VARIABLES	(1) Savings index	(2) Weddings number	(3) Immigrants number	(4) Welfare index
Coltan(j) X pc(t)	0.12**	0.19**	0.45***	0.36***
	(0.05)	(0.08)	(0.17)	(0.08)
C(j) X pc(t) X SB(jt)	-0.00	0.00	0.02	0.01
	(0.01)	(0.02)	(0.04)	(0.02)
C(j) X pc(t) X SB(jt) X Army(jt)	0.00	0.02	0.04	0.03
	(0.01)	(0.02)	(0.05)	(0.03)
C(j) X pc(t) X SB(jt) X Militia(jt)	0.02	0.07***	0.14***	0.09***
	(0.01)	(0.02)	(0.04)	(0.02)
Observations	3,582	3,466	3,523	2,669
R-squared	0.37	0.54	0.41	0.53

Panel B: Gold price

VARIABLES	(1) Savings index	(2) Weddings number	(3) Immigrants number	(4) Welfare index
Gold(j) X pg(t)	-0.06	-0.00	-0.02	-0.01
	(0.05)	(0.10)	(0.13)	(0.09)
G(j) X pg(t) X SB(jt)	-0.00	-0.02	-0.04*	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)
G(j) X pg(t) X SB(jt) X Army (jt)	0.00	0.04**	0.09***	0.03***
	(0.01)	(0.02)	(0.02)	(0.01)
G(j) X pg(t) X SB(jt) X Militia(jt)	0.00	0.03*	0.07***	0.02
	(0.01)	(0.01)	(0.02)	(0.01)
Observations	3,582	3,466	3,523	2,669
R-squared	0.37	0.54	0.40	0.51

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1 at the support village (where households are located), disaggregated by whether the support village was under a monopoly of violence held by an external armed actor, the FARDC, or a militia, including village and regional militia, and adds controls for the location suitability for a stationary bandit. Since a stationary bandit ($SB_{jt} = 1$) is either affiliated to a militia ($Militia_{jt} = 1$), to the FARDC ($Army_{jt} = 1$), or to an external organization ($External_{it} = 1$), $SB_{jt} = Militia_{jt} + External_{jt} + Army_{jt}$. Thus the additional effect of having an external stationary bandit, a stationary bandit from a (regional or village) militia, or a stationary bandit from the FARDC can be read respectively on the coefficients on the interaction that includes only SB_{jt}, $Militia_{jt}$ X SB_{jt}, and $Army_{jt}$ X SB_{jt}. Panel A presents the results for the coltan price and Panel B for the gold price. Column (1) presents the standardized (mean zero, standard deviation of one) household index for savings/investment. It uses as dependent variable an index that uses variables collected at the household level in the random sample of households in each village. For these variables, only household respondents who were settled in the village before 2000 were included to control for compositional effects due to migration. The data of these households is then collapsed at the household*year level to reduce concerns of within village*year intra-cluster correlation. Column (2) uses as dependent variable the logarithm of the number of weddings (plus one). Column (3) presents the effects on the log of the number of migrants (plus one). Column (4) uses a standardized welfare index (mean zero, standard deviation of one), constructed using principal components of the household savings index, the logarithm of weddings, and the logarithm of the number of immigrants. All regressions include year fixed effects, municipality fixed effects, and standard errors are clustered at the level of the municipality. All regressions include the following controls. First, I regress presence of a stationary bandit on all geographic characteristics (distance to a river, to a road, to a lake, to a park, to Rwanda, to Goma, to Bukavu, to Uganda, to a bridge, to a local airport). The regression allows to create a a propensity score, which is the predicted probability that a given location has a stationary bandit, based on the geographic characteristics. Then, I include in as controls the propensity score interacted with year dummies to account for time-varying effects of a location suitability for stationary bandits.

Table F.11: Essential functions of a state and household welfare—Effect of stationary bandits, OLS with leads and lags

VARIABLES	(1) Savings index	(2) Weddings Number	(3) Immigrants Number	(4) **Welfare index**	(5) **Welfare index**	(6) **Welfare index**	(7) **Welfare index**
Militia(jt)	0.03	0.16***	0.25**	0.19***	0.20***	0.26***	0.26***
	(0.03)	(0.05)	(0.12)	(0.06)	(0.06)	(0.07)	(0.07)
External(jt)	0.00	-0.13**	-0.26**	-0.11*	-0.05	-0.10	-0.04
	(0.03)	(0.06)	(0.13)	(0.06)	(0.07)	(0.06)	(0.07)
Army(jt)	0.05	0.11*	0.29*	0.20***	0.33***	0.33***	0.21***
	(0.05)	(0.06)	(0.15)	(0.07)	(0.09)	(0.09)	(0.07)
Militia(jt+1)	0.01	-0.02	0.36***	0.07	0.06		
	(0.03)	(0.06)	(0.10)	(0.06)	(0.05)		
Militia(jt-1)	-0.00	0.02	0.13	0.08	0.06		
	(0.04)	(0.05)	(0.11)	(0.06)	(0.06)		
Militia(jt-2)	0.05	-0.01	-0.01	0.01	-0.00		
	(0.03)	(0.05)	(0.11)	(0.07)	(0.07)		
External(jt+1)	0.02	-0.03	0.23**	0.09		0.08	
	(0.03)	(0.05)	(0.11)	(0.06)		(0.06)	
External(jt-1)	0.05	-0.02	0.07	0.05		0.04	
	(0.03)	(0.05)	(0.10)	(0.05)		(0.05)	
External(jt-2)	0.00	-0.05	-0.06	-0.04		-0.06	
	(0.03)	(0.05)	(0.11)	(0.06)		(0.06)	
Army(jt+1)	0.01	0.06	0.04	0.05			0.04
	(0.04)	(0.08)	(0.13)	(0.08)			(0.08)
Army(jt-1)	-0.05	0.08	0.17	0.06			0.05
	(0.06)	(0.06)	(0.14)	(0.06)			(0.06)
Army(jt-2)	0.06	0.08	0.21	0.21***			0.20***
	(0.06)	(0.07)	(0.14)	(0.08)			(0.08)
Observations	2,985	2,979	2,973	2,314	2,314	2,314	2,314
R-squared	0.38	0.56	0.41	0.52	0.52	0.52	0.52
Leads and lags	YES	YES	YES	YES	YES	YES	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Standard errors in parentheses. This table presents the estimates with leads and lags from specification 2, including as independent variables $Militia_{jt}$, $External_{jt}$, $Army_{jt}$, and respectively using as dependent variables the savings index, the number of celebrated weddings, the number of immigrants, and the index of household welfare. Standard errors are clustered at the level of the municipality. The results are unchanged excluding such controls. Columns (1)-(4) respectively use as dependent variables the savings index, the number of celebrated weddings, the number of immigrants, and the index of household welfare and include the one period lead and the one and two periods lags for $Militia_{jt}$, $External_{jt}$, $Army_{jt}$. Columns (5)-(7) include respectively only the leads and lags for $Militia_{jt}$, $External_{jt}$, $Army_{jt}$. All regressions include year fixed effects, municipality fixed effects, and controls for $p^{US}_{c,t}$ and $p^{US}_{g,t}$.

Table F.12: Essential functions of a state and household welfare—Instrumental variable approach, first-stage

PANEL A: mines

VARIABLES	(1) **Village militia**	(2) **Regional militia**	(3) **External Tutsi**	(4) **External Hutu**	(5) **Congolese Army**
POST(t) X TARGET(j)	-0.86***	-0.69***	-0.86***	-0.39***	
	(0.03)	(0.04)	(0.02)	(0.10)	
Observations	1,872	1,977	2,240	2,240	2,240
R-squared	0.50	0.62	0.62	0.60	0.56
F test model	788	260.1	1449	16.71	0

PANEL B: Support villages

VARIABLES	(1) **Village militia**	(2) **Regional militia**	(3) **External Tutsi**	(4) **External Hutu**	(5) **Congolese Army**
POST(t) X TARGET(j)	-0.82***	-0.91***	-0.87***	-0.45***	
	(0.03)	(0.03)	(0.01)	(0.10)	
Coltan(j) X pc(t)	-0.05*	-0.12***	0.03	0.03	0.05
	(0.03)	(0.03)	(0.02)	(0.04)	(0.05)
Gold(j) X pg(t)	-0.04	-0.08**	-0.06**	-0.03	0.24***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.05)
Observations	2,390	2,390	2,390	2,390	2,390
R-squared	0.47	0.45	0.64	0.56	0.60
F test model	262.7	469.4	1626	7.821	13.04

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors in parentheses. This table presents the first stage of the 2SLS specification that instruments the presence of a stationary bandit with the timing and targeting of a national peace agreement in 2003. Columns (1)-(2) use village militia and regional militia. Columns (3) to (5) decompose non-militia armed organizations into the Congolese army (FARDC), external armed actors of Tutsi ethnic group (or that represent the interests of Tutsi groups), and the same for armed groups of Hutu ethnicity (mostly the FDLR and Interahamwe). Village militia are stationary bandits that emerge in the municipality as a popular mobilization. Regional militia are popular mobilizations that emerge in the region, but not in the municipality. External organizations are not from the area, most often "foreign" ethnic groups. External organizations affected by the peace agreement include only the RCD. Panel A regressions include mining site (except column 1) and year fixed effects, and Panel B include support village and year fixed effects. The sample size examining the presence of village militia at the mines is smaller because the presence of village militia *at the mines* were only measured in Sud Kivu and because it is a rare occurrence. For that reason, I do not include mine fixed effects on column 1 of Panel A (the coefficient cannot be estimated due to the small sample size). Village militia at the village, however, were measured in both provinces. A discussion of the time window is presented in Section 5.3. In all regressions, standard errors are clustered at the level of the municipality.

Table F.13: Essential functions of a state and household welfare—Instrumental variable approach, estimation with time trends

VARIABLES	(1) Savings Index	(2) Weddings Number	(3) Immigrants Number	(4) **Welfare index**	(5) Savings Index	(6) Weddings Number	(7) Immigrants Number	(8) **Welfare index**
SB(jt)	0.04	0.51**	2.29***	1.01***	0.22*	-0.22	1.69***	0.85***
	(0.13)	(0.25)	(0.71)	(0.30)	(0.12)	(0.20)	(0.58)	(0.29)
Coltan(j) X pc(t)	-0.02	0.06	0.44*	0.17	-0.22***	-0.14	0.07	-0.24**
	(0.07)	(0.10)	(0.26)	(0.11)	(0.05)	(0.11)	(0.27)	(0.12)
Gold(j) X pg(t)	-0.11*	0.07	0.11	0.06	-0.13*	-0.07	0.01	-0.02
	(0.06)	(0.10)	(0.26)	(0.12)	(0.07)	(0.10)	(0.23)	(0.12)
Observations	1,230	1,341	1,339	1,035	1,330	1,485	1,396	1,111
Number of clusters	123	153	152	121	133	161	158	129
Type	MIL	MIL	MIL	MIL	EXT	MIL	MIL	MIL

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the 2SLS estimates for the effect of different types of stationary bandits on household welfare, including different time trends for each target group. The dummies $SB(it), Militia$ and $SB(it), External$ respectively indicate the presence of a (regional or village) militia stationary bandit, and the presence of an external stationary bandit. The coefficients are the IV coefficients, which are estimated by instrumenting $SB(it), Militia$ (and then $SB(it), External$) with $POST_t$ X $TARGET_i$. Panel A restricts the sample to support villages in which there is a militia stationary bandit in 2002 plus support villages in which there is no stationary bandit in 2002. Presence of a militia stationary bandit ($SB(it), Militia$) is instrumented with the variable $POST_t$ X $SB, Militia_{2002}$. Panel B restricts the sample to support villages in which there is an external stationary bandit in 2002 plus support villages in which there is no stationary bandit in 2002. Presence of n external stationary bandit ($SB(it), External$) is instrumented with the variable $POST_t$ X $SB, External_{2002}$. Column (1) presents the standardized (mean zero, standard deviation of one) household index for savings/investment. It uses as dependent variable an index that uses variables collected at the household level in the random sample of households in each village. For these variables, only household respondents who were settled in the village before 2000 were included to control for compositional effects due to migration. The data of these households is then collapsed at the household*year level to reduce concerns of within village*year intra-cluster correlation. Column (2) uses as dependent variable the logarithm of the number of weddings (plus one). Column (3) presents the effects on the log of the number of migrants (plus one). Column (4) uses a standardized welfare index (mean zero, standard deviation of one), constructed using principal components of the household savings index, the logarithm of weddings, and the logarithm of the number of immigrants. All regressions include year fixed effects, municipality fixed effects, target group specific linear time trends, and standard errors are clustered at the level of the municipality. Figure F.10 provides a balance test, Figure F.11 (and Table F.12) presents the first stage, and a graphical representation of the reduced form results is provided in Figure F.12.

Table F.14: Robustness checks—intensive margin index

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Coltan(j) X pc(t)	-0.12***	-0.13***	-0.12***	-0.12***	-0.08***	-0.06**	-0.17***	-0.17***	-0.11***	-0.12***	-0.12***	-0.12***	-0.07**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)	(0.05)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Gold(j) X pg(t)	0.16***	0.29***	0.13**	0.47**	-0.03*	0.42***	0.16***	0.17***	0.15**	0.16***	0.16***		0.06*
	(0.06)	(0.09)	(0.06)	(0.20)	(0.02)	(0.10)	(0.06)	(0.06)	(0.06)	(0.03)	(0.03)		(0.03)
C(j) X pc(t) X D(a)(j)							0.09						
							(0.06)						
pc(t) X D(a)(j)							-0.04						
							(0.03)						
C(j) X pc(t) X D(r)(j)								0.09					
								(0.07)					
pc(t) X D(r)(j)								-0.05					
								(0.03)					
Coltan(j) X local pc(t)												0.23**	
												(0.09)	
Observations	4,244	4,244	4,244	4,208	3,995	3,995	4,244	4,244	3,556	4,244	4,244	4,247	4,244
R-squared	0.81	0.81	0.82	0.82			0.81	0.81	0.80	0.81	0.81		0.81
Mineral time trends	NO	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
Region*Year FE	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Arellano-Bond	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO
Weights	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO
Cluster	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	R*Y	YES	YES
Model	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	OLS
Number of groupreshapeid					239	239						239	

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the robustness checks on specification 1 at the support village, using the intensive margin index as a dependent variable. Column (1) implements specification 1. Column (2) adds mineral time trends. Column (3) adds region*year fixed effects. Column (4) adds leads and lags of the regressor. Column (5) implements Arellano-Bond GMM estimation. Column (6) implements Arellano-Bond GMM estimation with mineral time trends. Column (7) includes the interaction with the dummy indicating distance to local airports, $C_j\ p^{US}_{c,t} D^a_j$, as well as the corresponding interaction term $p^{US}_{c,t} D^a_j$. Column (8) includes in addition the analogous interactions for the distance to the road, $C_j\ p^{US}_{c,t} D^r_j$ and $p^{US}_{c,t} D^r_j$. In Column (9), I implement a weighted regression using working memory scores as weights. Column (10) replicates the main specification, with no clustering the standard errors. In column (11) standard errors are clustered at the region*year level. Column (12) instruments the local price of coltan with its world price. Column (13) replaces the time invariant coltan (gold) endowment dummy with an indicator of past coltan (gold) output.

Table F.15: Explaining the intensification of the essential functions of a state—Excluding the Congolese army (FARDC)

PANEL A: Unconditional

VARIABLES	(1) **Poll Tax**	(2) **Market Tax**	(3) **Toll Booth**	(4) **Mill Tax**	(5) **Tax Index**	(6) **Fiscal Admin**	(7) **Justice Admin**	(8) **Intensive Index**
Coltan(j) X pc(t)	0.03	-0.03*	-0.00	0.00	-0.00	-0.05**	-0.04**	-0.05
	(0.03)	(0.02)	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.04)
Gold(j) X pg(t)	0.06	0.08**	0.03	-0.01	0.14	0.09**	0.10**	0.19**
	(0.05)	(0.03)	(0.03)	(0.02)	(0.08)	(0.04)	(0.05)	(0.09)
Observations	3,572	3,560	3,572	3,572	3,560	3,572	3,572	3,560
R-squared	0.49	0.54	0.53	0.47	0.54	0.53	0.51	0.55

PANEL B: Conditional

VARIABLES	(1) **Poll Tax**	(2) **Market Tax**	(3) **Toll Booth**	(4) **Mill Tax**	(5) **Tax Index**	(6) **Fiscal Admin**	(7) **Justice Admin**	(8) **Intensive Index**
Coltan(j) X pc(t)	-0.01	-0.04**	-0.00	-0.00	-0.05	-0.09***	-0.09***	-0.12***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.03)	(0.02)	(0.02)	(0.03)
Gold(j) X pg(t)	0.01	0.08***	0.03	-0.01	0.09*	0.06*	0.07*	0.12**
	(0.02)	(0.03)	(0.03)	(0.02)	(0.05)	(0.04)	(0.04)	(0.05)
Observations	3,533	3,521	3,572	3,533	3,521	3,533	3,533	3,521
R-squared	0.82	0.68	0.53	0.55	0.82	0.74	0.75	0.85

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1, excluding the FARDC, and using as dependent variables the vector of "sophisticated" taxes in Columns (1) through (4) (poll taxes, food market taxes, toll booths at the village, mill tax), a tax sophistication index (Column 5), a dummy for fiscal administration at the village (Column 6), a dummy for justice administration at the village (Column 7), and an overall intensive margin index (Column 8). The fiscal sophistication index (top row) was constructed as follows. First, for each tax instrument $i \in \{1, N\}$, for all years t and villages j in which a stationary bandit uses it, I compute the proportion of observations in which the stationary bandit holds a fiscal administration. This yields a weight $w_i \in \{0, 1\}$ for each tax that proxies for the degree to which tax instrument i is associated with investments in fiscal administration. A high w_i thus indicates that tax i is associated with a high cost of collection. Then, for each tax vector observed at year t in village j, I compute the following weighted average: $I_{jt} = \sum_{i=N}^{i=1} = w_i T_{ijt}$, where w_i are the tax instrument weights and T_{it} is a dummy indicating whether tax i is collected at time t in village j. For interpretation purposes, I then normalize I_{jt} by subtracting its mean and dividing by its standard deviation: $I_{jt}^{normalized} = \frac{I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}}{\sqrt{\frac{1}{n}\sum_j \sum_t \left(I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}\right)^2}}$. The overall intensive margin index is constructed using principal component analysis for ordinal scale items on the tax sophistication variable and an index of administrative development, and the outcome is then normalized to mean zero and standard deviation of one. The index of administrative development is constructed principal component analysis for ordinal scale items on the following two dummies: village fiscal administration, village justice administration. As with the other indexes, I then normalized to units of standard deviation centered around the mean. To separate selection effects induced by a change in composition from changes of stationary bandits' behavior, Panel B shows the results including stationary bandit organization fixed effects. For the conditional analysis, identification stems from changes in intensive margin outcomes within organizations, within village, across time. All regressions include year fixed effects, municipality fixed effects, and standard errors are clustered at the level of the municipality. All regressions exclude the FARDC by coding intensive margin outcomes as missing when conducted by the FARDC.

Table F.16: Explaining the intensification of the essential functions of a state—Including only the Congolese army (FARDC)

VARIABLES	(1) **Poll Tax**	(2) **Market Tax**	(3) **Toll Booth**	(4) **Mill Tax**	(5) **Tax Index**	(6) **Fiscal Admin**	(7) **Justice Admin**	(8) **Intensive Index**
Coltan(j) X pc(t)	-0.08	0.00	-0.02	-0.00	-0.09	-0.05*	-0.10*	-0.19
	(0.08)	(0.05)	(0.05)	(0.05)	(0.16)	(0.03)	(0.05)	(0.16)
Gold(j) X pg(t)	-0.08	0.09	0.04	0.02	0.09	-0.04	-0.13*	-0.04
	(0.08)	(0.07)	(0.08)	(0.05)	(0.18)	(0.04)	(0.07)	(0.17)
Observations	713	712	713	713	712	713	713	712
R-squared	0.83	0.83	0.90	0.90	0.84	0.91	0.89	0.84

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results from specification 1, including only the FARDC, and using as dependent variables the vector of "sophisticated" taxes in Columns (1) through (4) (poll taxes, food market taxes, toll booths at the village, mill tax), a tax sophistication index (Column 5), a dummy for fiscal administration at the village (Column 6), a dummy for justice administration at the village (Column 7), and an overall intensive margin index (Column 8). The fiscal sophistication index (top row) was constructed as follows. First, for each tax instrument $i \in \{1, N\}$, for all years t and villages j in which a stationary bandit uses it, I compute the proportion of observations in which the stationary bandit holds a fiscal administration. This yields a weight $w_i \in \{0, 1\}$ for each tax that proxies for the degree to which tax instrument i is associated with investments in fiscal administration. A high w_i thus indicates that tax i is associated with a high cost of collection. Then, for each tax vector observed at year t in village j, I compute the following weighted average: $I_{jt} = \sum_{i=N}^{i=1} = w_i T_{ijt}$, where w_i are the tax instrument weights and T_{it} is a dummy indicating whether tax i is collected at time t in village j. For interpretation purposes, I then normalize I_{jt} by subtracting its mean and dividing by its standard deviation: $I_{jt}^{normalized} = \frac{I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}}{\sqrt{\frac{1}{n}\sum_j \sum_t \left(I_{jt} - \frac{1}{n}\sum_j \sum_t I_{jt}\right)^2}}$. The overall intensive margin index is constructed using principal component analysis for ordinal scale items on the tax sophistication variable and an index of administrative development, and the outcome is then normalized to mean zero and standard deviation of one. The index of administrative development is constructed principal component analysis for ordinal scale items on the following two dummies: village fiscal administration, village justice administration. As with the other indexes, I then normalized to units of standard deviation centered around the mean. To separate selection effects induced by a change in composition from changes of stationary bandits' behavior, Panel B shows the results including stationary bandit organization fixed effects. For the conditional analysis, identification stems from changes in intensive margin outcomes within organizations, within village, across time. All regressions include year fixed effects, municipality fixed effects, and standard errors are clustered at the level of the municipality. All regressions include only the FARDC by coding intensive margin outcomes as missing when conducted by other armed actors than the FARDC. Since only one organization is included in the analysis, the conditional and unconditional regressions are identical, and I thus only report one.

Table F.17: Survey and ACLED violent events

VARIABLES	(1) ACLED 1km	(2) ACLED 2km	(3) ACLED 5km	(4) ACLED 10km	(5) ACLED 15km	(6) ACLED 20km	(7) ACLED 25km	(8) ACLED 50km
Municipality is attacked (jt), from survey	0.00	0.00	0.00	0.02**	0.03**	0.05***	0.05***	-0.00
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Observations	1,875	1,875	1,875	1,875	1,875	1,875	1,875	1,875
R-squared	0.17	0.27	0.22	0.28	0.36	0.42	0.44	0.50
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Municipality FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents the results on a linear probability model of whether a battle is recorded by ACLED in the proximity on a survey municipality on whether a violent event is recorded in that municipality using the survey. To assign violent events recorded by ACLED to the survey municipalities, I computed the number of geo-located ACLED violent events that were located within a given perimeter of the survey support village. From left to right, columns (1) to (8) report the results using the number of events of ACLED near the support village using circles centered around the support village and of radius 1km (column 1), 2km (column 2), 5km (column 3), 10km (column 4), 15km (column 5), 20km (column 6), 25km (column 7), 50km (column 8). Standard errors are clustered at the village level and all regressions include village and year fixed effects. To construct the variable “attack” from ACLED, I take the total of events recorded by ACLED, and subtract all events that are not attacks for each year*municipality observation. The non-violent events are: strategic transit of troops, riots, non violent transfer of territory, non violent events in general, and whether an armed group changes a headquarter basis.

Table F.18: Replication of the main result using ACLED data

VARIABLES	(1) ACLED 1 km	(2) ACLED 2 km	(3) ACLED 5 km	(4) ACLED 10 km	(5) ACLED 15 km	(6) ACLED 20 km	(7) ACLED 25 km	(8) ACLED 50 km
Coltan(j) X pc(t)	-0.00	-0.00	0.02	0.05**	0.11***	0.12***	0.16***	0.08*
	(0.00)	(0.01)	(0.02)	(0.02)	(0.03)	(0.04)	(0.04)	(0.05)
Gold(j) X pg(t)	0.00	-0.00	0.01	-0.01	0.01	0.04	0.08**	0.02
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Observations	1,875	1,875	1,875	1,875	1,875	1,875	1,875	1,875
R-squared	0.17	0.27	0.22	0.28	0.36	0.43	0.44	0.50
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Municipality FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. This table presents replication of the main result using ACLED data for attacks. Columns (1) to (8) report the results using the number of events of ACLED near the support village using circles centered around the support village and of radius 1km (column 1), 2km (column 2), 5km (column 3), 10km (column 4), 15km (column 5), 20km (column 6), 25km (column 7), 50km (column 8). To construct the variable "attack" from ACLED, I take the total of events recorded by ACLED, and subtract all events that are not attacks for each year*municipality observation. The non-violent events are: strategic transit of troops, riots, non violent transfer of territory, non violent events in general, and whether an armed group changes a headquarter basis. Standard errors are clustered at the village level and all regressions include village and year fixed effects.

G Further considerations

G.1 Violence and state formation

Demand for coltan brings stationary bandits and protection. However, it also induces violence. The statistical variation used in this paper is not well-suited to separate the effect of mineral demand on the creation of the essential functions of the state from its effect on violence, which results from contestation. The coltan demand shock jointly creates the incentives for more state-like structures (there is more to tax and protect) and for more violence between armed groups (there is more value for the prize). I next illustrate this point. Conceptualize the degree of state function as the probability that violence that occurs is produced by the stationary bandit, p. A movement along this continuum from zero to one defines the station formation process. Let p be a function of income, y, and of the effort made by the stationary bandit at providing security, s, which can be a function of income—since income determines the returns of providing security.

The degree of state function can thus be summarized by $p(s(y), y)$, where $p_s(s(y), y) > 0$ and $p_y(s(y), y) < 0$, since when income is higher, the threat from contestation increases. Thus:

$$\frac{\partial p(s(y), y)}{\partial y} = p_s(s(y), y)\frac{\partial s}{\partial y} + p_y(s(y), y)$$

The term $p_s(s(y), y)\frac{\partial s}{\partial y}$, is the effect on the stationary bandit's investment in security. The second term, $p_y(s(y), y)$, is the effect on contestation (battles). The coltan demand shock leads to the two effects combined: stationary bandits form, they make effort to protect property rights, but there is also a spike in attempted attacks that reflects contestation. Thus, the increase in the degree of state function I observe is a lower bound for the effect on stationary bandit effort to develop state functions. Indeed, in response to the shock, attacks increase (Figure 3), but also monopolies of violence and security provision emerge (Figure 4).

G.2 Time frame and state formation

While the gold demand shock has permanent effects, the coltan demand shock persisted only a few years after the price reversal. Yet, documented essential functions of the modern state, for instance, usually took centuries to form and persist. This paper sheds little light on the formation of the modern state. Through its focus on the emergence of the essential functions of the state, the paper relates instead the sociological view of state formation (Tilly, 1985). Modern states relate to this paper as a selected successful sample of such states-in-the-making process, many of which "less successful and smaller in scale, we call organized crime." Some will never turn into a modern state—feudal local Lords, whose actions underpin the formation of the modern state, probably did not plan the creation of modern nation states. Yet, armed groups dismantled in 2004 as part of a political deal, thus observed persistence is likely a lower-bound.

G.3 Additional discussion on the role of the Congolese army (FARDC)

Two key features are essential to understand the role of the FARDC:

- **Criminal composition of the FARDC:** First, the FARDC was founded in 2004 as a merger of armed groups at the end of the war and is one of the major congregations of criminal activities of armed actors in the DRC today. Most of the members of the FARDC arise from armed groups and maintain their criminal networks of command and of illegal taxation. This criminal composition is very well documented in detailed work by sociologists (Verweijen, 2013, 2018). For instance, Baaz and Verweijen (2013) recommend: "The FARDC should avoid creating homogeneous units out of former rebels who have been integrated. They should be retrained and redeployed", and note as an illustrative example: "A similar network, which has now begun to fray, regroups RCD officers from the east who were integrated into the FARDC in 2003. By 2011, more than half of the command positions in North and South Kivu were held by officers from this group. Some of the most prominent of these maintained their positions thanks to General Gabriel Amisi, former RCD officer and commander of the land forces between 2006–12."

The FARDC remains one of the major perpetrators of human rights abuses and factions of the FARDC repeatedly mutinied to re-create existing armed groups. For instance, United Nations Joint Human Rights Office (2016) reports that of 7,388 human rights violations recorded in DRC between January 1st, 2014 and March 1st 2016, 24% were perpetrated by the FARDC—4,032 by any state agent (55%).

- **Criminal activities of the FARDC:** Second, it is also well documented that the FARDC systematically relies on criminal activities for the survival of its members, including the emergence of essential functions of a state through illicit activities in enclaves (Verweijen, 2013, 2018). The FARDC systematically organizes extortion networks, the sale of private protection for private gain, the collection of illegal taxes, and the control of the mineral trade and the cross-border smuggling of illegal goods (timber, cacao, and coffee in the DRC/Ugandan border is just an example; illicit taxes in rich areas linked to gold income is another, which is the core of this paper).

  Organized crime, rather than being an anomaly inside the FARDC, is a driving force. Baaz and Verweijen (2013) describe the way the entire structure functions as organized crime: "Subordinates are obliged to pay regular amounts to superiors, often referred to as rapportage ('bringing in')." One distinctive feature of the FARDC is that in the second period of the sample used in this paper, it gains better control over sources of criminal revenues than many existing armed groups.

Inclusion of the FARDC, a dominant form of organized crime in the second period of the sample, is thus core to the argument of this paper. A fruitful conceptualization of the industrial organization of violence in the period I study is that high level agreements in 2004 allowed organized crime to operate under a new banner, which obtained the blessing of the international community due to its labeling as a state army. Most FARDC actors, which today continue to make significant profit from the very same activities that they used to conduct prior to their integration in the FARDC, are former Mayi-Mayi commanders and soldiers, former RCD officials, former CNDP, and former M23, which kept their structures of command.