

# ON THE ORIGIN OF STATES: STATIONARY BANDITS AND TAXATION IN EASTERN CONGO

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## Abstract

When do states arise? When do they fail to arise? This question has generated scholarship across the social sciences. A dominant view is that the origin of states lies in violent actors who impose a monopoly of violence in order to extract taxes (Carneiro, 1970, Claessen and Skalník, 1978, Tilly, 1985). One fundamental fact affects all existing studies on this question: statistics were the creation of established states. Therefore, while archaeological documentation has produced rich data on individual experiences of state formation, there is little disaggregated econometric evidence on the process, and causes, of state formation. As a foundation for this study, I organized the collection of village-level panel data on violent actors, managing teams of surveyors, village elders, and households in 380 war-torn areas of DRC. I introduce optimal taxation theory to the decision of violent actors to establish local monopolies of violence. The value of such decision hinges on their ability to tax the local population. A sharp rise in the global demand for coltan, a bulky commodity used in the electronics industry, leads violent actors to impose monopolies of violence and taxation in coltan sites, which persist even years after demand collapses. A similar rise in the demand for gold, easier to conceal and more difficult to tax, does not. However, the groups who nevertheless control gold sites are more likely to respond by undertaking investments in fiscal capacity, consistent with the difficulty to observe gold, and with well-documented trajectories of state formation in Europe (Ardant, 1975). The findings support the view that the expected revenue from taxation, determined in particular by tax base elasticity and costly investments in fiscal capacity, can explain the stages of state formation preceding the states as we recognize them today.

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# 1 Introduction

In a stateless economy, economic agents can use coercion to expropriate goods and services. Since uncoordinated expropriation depresses incentives to invest, organizing coercion under a monopoly of violence can generate large welfare gains (Bates, Greif, and Singh, 2002, Grossman, 1999, Hirshleifer, 1995).

When do violent actors establish a monopoly of violence? In this paper, I answer this question to uncover the first stages of state formation. A dominant view across social sciences is that states emerged through coercion by violent actors who create a monopoly of violence (Carneiro, 1970, Olson, 1993, Tilly, 1985, Weber, 1946).<sup>1</sup> Social scientists identify state formation as part of the “Great Transformation” because of the prosperity it generated and the reduction of violence it induced (Bates, 2011, Polanyi, 1944).<sup>2</sup> As a result, a large number of scholars have attempted to provide an explanation for the origins of the state. One fundamental fact affects the scholarship on state formation, however: statistics were the creation of states (Scott, 1999). While archaeological and sometimes historical documentation has produced extremely rich data on individual experiences of state formation, there is little disaggregated econometric evidence that allows to make causal inferences on the process and the causes of state formation.<sup>3</sup>

As a foundation for this study, I managed a team of data collectors in areas of east Democratic

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<sup>1</sup>The definition often adds the feature that violence ought to be “legitimate”. I discuss legitimacy below.

<sup>2</sup>In economics, Grossman (1994) argues: “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.”

<sup>3</sup>Mexico’s Oaxaca Valley prior to 200 A.D. and Polynesia in the turn of the 19th century are examples of extremely well-documented cases of pristine state formation (Marcus and Flannery, 1996). Claessen and Skalnik (1978), Keeley (1996), Kelly (2000) systematically document existing evidence across cases of stateless societies and Early states. The archaeological nature of the data nevertheless hampers our ability to make confident claims about the causes of state formation. Marcus and Flannery (1996) argue: “Monte Alban I was a society in transition from chiefdom to state, and cannot easily be fitted into one of these two evolutionary stages. Ecological functionalists could argue that Monte Alban’s great need for maize to feed its urban population made the subjugation of the entire Valley of Oaxaca necessary. Selectionists could argue that the “competitive advantage” conferred by Monte Alban’s large size made it likely that it would eliminate all competitors. Action theorists could argue that a series of aggressive Monte Alban rulers, like Hawaii’s Kamehameha, fought relentlessly to subdue the rest of the Valley of Oaxaca.” Marcus and Flannery (1996) also document that archaeological evidence often cannot reveal information on key outcomes, such as battles for conquest: “it can be difficult to distinguish between colonization and conquest, since a battle is one of the hardest events to document with archaeological evidence”. This provides a marked advantage to the approach deployed in this paper. The view that systematic disaggregated data that would allow to compare across experiences is insufficient is expressed by scholars of the Early state: “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).

Republic of Congo where the central state is virtually absent, in order to assemble a yearly panel data set of violent actors in 380 locations. The data allows me to identify types of violence, as well as village-level monopolies of violence and taxation by violent actors since 1995.

Using the data I assembled, I provide econometric evidence on the causes of monopolies of violence and taxation as a way to uncover the causes of the first stages of state formation. Drawing on the theory of optimal taxation, I develop an economic theory that can explain when violent actors may choose to establish monopolies of violence. If violent actors formed states in order to tax, the choice to form a state in one location must depend on the expected ability to raise tax revenues in that location. The key insight of the model is that the value of output in a particular location increases the returns to form a monopoly of violence in that location, and more so if output is observable to the tax collector. A positive demand shock on coltan in the year 2000, a bulky mineral, leads violent actors in my data to conquer locations endowed with coltan, establish a monopoly of violence and develop systems of taxation and provide protection. A later demand shock on gold, easier to conceal and hence more difficult to tax, does not have this effect in locations endowed with gold. However, the increase in the price of gold induces armed actors who own nevertheless the monopoly of violence in gold areas to develop heavier administration aimed at increasing the control over valuable, yet difficult to tax, economic activity.

Eastern Congo is a well-suited quasi-experimental ground to study the first steps of state formation. The Democratic Republic of Congo state is considered a “failed state” and was ranked the world’s second weakest state in 2013.<sup>4</sup> Violent actors have proliferated in the East and often use violence to rob populations. However, as in historical accounts of state formation, they often fight to establish territorial monopolies of violence, in which they develop elaborate taxation systems, provide protection and other public goods, and even obtain popular support.<sup>5</sup>

In the main result of the paper, I find that violent actors respond to an increase in the price of coltan by conquering coltan villages, in which they establish village-level monopolies of violence and create stable taxation systems, focused mostly on coltan output taxes, coltan labor taxes, and poll taxes. In the year 2000, innovations in the video-games industry led the demand for columbite-tantalite (coltan) to skyrocket.<sup>6</sup> Due to the demand shock, US price of coltan rose abruptly from 90 US\$ per kilogram to 590 US\$ per kilogram at the start of the year, and collapsed

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<sup>4</sup>Source: Fund For Peace (2013)

<sup>5</sup>See United Nations Security Council (2002), Nest, Grignon, and Kisangani (2011), Sanchez de la Sierra (2014) Stearns (2011) and Verweijen (2013). See also the RRMP program evaluation reports <http://www.rrmp.org>.

<sup>6</sup>See United Nations Security Council (2002), Nest (2011), Stearns (2011).

at the end of the year. To establish a causal relationship, I exploit this positive demand shock for coltan and compare the change in behavior of violent actors in villages endowed with coltan to the change in behavior of violent actors in other mining and agricultural villages. I further find that this effect is concentrated in villages in the proximity of local airports, precisely where trade costs for coltan are not prohibitively high.

However, tax revenues may not be the only mediator of the relationship between the coltan price and the behavior of violent actors. A rise in population density due to a migration response, for instance, could have increased the demand for order, leading to stationary bandits. To isolate other channels from the rise in tax revenues, I use a similar sharp positive demand shock for gold, as profitable for miners, but whose output, easy to conceal, is impossible to tax. September 11<sup>th</sup> and the resulting 2001-2002 global recession led investors to rush to safe investments such as gold, causing its price to rise sharply. I find that violent actors *do not* create monopolies of violence or taxation in response to the increase in the price of gold, whose output is impossible to tax. The effect of the coltan shock, and its contrast with the effect of the gold shock, suggests that local conditions that increase feasible tax revenues to violent actors are a driver of state formation.

A large body of work in economics studies the decisions of government, in particular investments in state capacity (Acemoglu, Garcia-Jimeno, and Robinson, 2014, Acemoglu and Robinson, 2006, Acemoglu, Ticchi, and Vindigni, 2006, Besley and Persson, 2009, North and Weingast, 1989). However, with the exception of ongoing work, research in economics usually takes the existence of the state as given and focuses on changes in state capacity as choices of existing states. Organizing a data collection project in a virtually stateless environment, I provide an explanation for the first steps of state formation that precede the behaviors usually studied in political economy.

This paper also contributes conceptually to unresolved debates about the causes of state formation which have implications for the conceptualization of states.<sup>7</sup> On the one hand, voluntaristic theories argue that states emerged as a result of a mutually beneficial social contract (Hobbes, 1651, Rousseau, 1762). On the other hand, conflict theories of state formation link the origin of states to the creation of monopolies of violence through coercion and conquest, and view states as successful organized crime (Bates, Greif, and Singh, 2002, Carneiro, 1970, Gennaioli and Voth, 2011, Grossman, 1997, Olson, 1993, Tilly, 1985). With rare exceptions, existing theories do not

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<sup>7</sup>The literature on state formation is separated between early and modern state formation. The literature on early state formation is reviewed in Claessen and Van de Velde (1991) and Claessen and Skalnik (1978).

explain why states would have emerged in certain locations, but failed in other.<sup>8</sup> Drawing on the data I assembled, I provide support for conflict theories of state formation, but I go a step further — yet not ruling out contractarian views of the state as relevant for the historical process. I use optimal taxation theory to explain why organizations of violence would form monopolies of violence in certain locations and not others as a result of a taxation problem. I then apply econometric analysis to show that monopolies of violence are more likely to emerge, through territorial conquest, when feasible tax revenues are expected to be high. This empirical result supports the theory that states initially emerge from violent actors when violent actors can expect their tax revenues to be high.

This paper contributes to the growing knowledge of civil war in economics in three ways, and complements the study of rebel governance in political science. First, I assembled information on armed groups' behavior into a large disaggregated data set, improving the empirical basis of the civil war literature. Blattman and Miguel (2010) indeed indicate that the study of civil war is limited by the absence of high quality disaggregated data. Second, I find that demand for labor-intensive commodities *increases* violence aimed at establishing monopolies of violence and taxation, while it leaves the rates of pillages and arbitrary expropriations unaffected. These findings contrast with Dube and Vargas (2013), who find that a rise in the price of a labor-intensive commodity *decreases* observed violence, which they interpret to be driven by a change in the opportunity cost of fighting. By adding taxation to the choices of armed groups previously considered, I thus complement existing explanations for the deployment of violent strategies (Dal Bó and Dal Bó, 2011). Third, by exploiting two exogenous sharp demand shocks, this paper also contributes to this field on the grounds of identification (Angrist and Kugler, 2008, Bazzi and Blattman, 2011, Besley and Persson, 2008, Dube and Naidu, 2010, Dube and Vargas, 2013, Koenig, Rohner, Thoenig, and Zilibotti, 2015, Nunn and Qian, 2012). In political science, this paper introduces high quality disaggregated data and causal identification to the growing field of rebel governance, which, with some notable exceptions, usually relies on qualitative evidence (Arjona, 2008, Mamphilly, 2011, Weinstein, 2007). Furthermore, I complement this field by linking the formation of monopolies of violence by violent actors to the first stages of state formation, and I ground the conceptual analogy on systematic empirical evidence.

Having contributed to both the civil war literature and the state formation literature, I link

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<sup>8</sup>See Carneiro (1970), Herbst (2011), Mayshar, Moav, and Neeman (2011), Vansina (1978, 2005) for some explanations.

the two by providing an explanation of why actors that engage in violence may form monopolies of violence. While political economy takes the monopoly of violence as given, the study of civil war in economics focuses on the individual choices to produce or predate, but largely ignores the possibility (or the relevance) to organize violence (Besley and Persson, 2009, Collier and Hoeffler, 2004, Dal Bó and Dal Bó, 2011, Humphreys and Weinstein, 2006, Weinstein, 2007).

Finally, this paper refines the literature on rentier states and the resource curse (Bannon and Collier, 2003, Bates and Lien, 1985). My findings challenge its most basic interpretation. Advocates of this view suggest that when states have access to valuable resources, they will be less dependent on the population for taxes and hence will develop more predatory institutions and will be more prone to violence. This literature ignores that the population needs to be taxed when extraction of resources is labor intensive. I find that natural resources could facilitate the formation of institutions which rely on taxing the population, in a context where production is labor-intensive and rulers need to tax labor directly.

The remainder of the paper is organized as follows. Section 2 offers contextual background. Section 3 places the context in the broader literature of state formation and presents the overarching question in this paper. Section 4 presents the theory. Section 5 describes the data and Section 6 presents the empirical strategy. Section 7 presents the results. Section 9 concludes.

## 2 Institutional context

As a result of the collapse of the central state, armed groups in the Democratic Republic of Congo have proliferated since the 1990's.<sup>9</sup> To finance their operations, armed groups collect taxes on the mineral sector and other activities. There are approximately 40 recorded armed groups.<sup>10</sup>

### 2.1 The conflicts

This study covers two historical phases: the Second Congo War (1998-2003) and the “post-conflict” period (2003-2013).

The Second Congo War (1998-2003) involved a large number of armed groups, and is referred

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<sup>9</sup>The Democratic Republic of Congo was named Zaire until 1997.

<sup>10</sup>Source: United Nations Security Council ambassadors, <http://www.reuters.com/article/2013/10/06/us-congo-democratic-un-idUSBRE9950IZ20131006>

to as the “Great African War”. In 1998, the Rassemblement Congolais pour la Démocratie (RCD) launched an offensive to overthrow the then DRC president in office, Laurent-Désiré Kabila.<sup>11</sup> The coup did not succeed, but a myriad of RCD units maintained control of the Eastern provinces, while the Congolese state defended the West. The RCD struggled to dominate the rural areas, where it faced resistance by the self-defense groups known as the Mayi-Mayi and by the Forces De Libération du Rwanda (FDLR) among other groups. These groups formed unstable alliances, and the challenge to maintain structures of command led to discipline problems within their organizations. The war also involved the participation of nine foreign armies. More than thirty local militia were active, mostly in the east of the country (Ngonzola-Ntalaja, 2002).

Despite support from the UN Peacekeeping force (MONUSCO), the Congolese state struggled to regain control over the Eastern Provinces in the “post-conflict” period (2003-2013). Following a peace agreement signed in Sun-City (South-Africa) in 2003, the Rassemblement Congolais pour la Démocratie (RCD) agreed to vacate the East of the Congo and integrate the national government. Following the RCD departure, the Forces De Libération du Rwanda (FDLR) and local self defense groups increased their territorial control. Only in 2009, the Congolese army, together with the United Nations peacekeeping force and Rwanda, led a major operation against the FDLR. This operation, Kimia II, successfully weakened the link between the FLDR and its former tax base, although it failed to eradicate it. Armed groups continue to operate in the East, where they control up to 95% of the territory in some administrative divisions.<sup>12</sup> Between May 2012 and November 2013, a new armed group, the M23, established its own monopoly of violence in a large territory, and created a functional administration including a Ministry of the Interior, of Foreign Affairs, and of Agriculture.<sup>13</sup> These groups are motivated mostly by political goals, the organization of self-defense, and economic interests, among a myriad of motives.<sup>14</sup>

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<sup>11</sup>The First Congo War lasted from 1996 to 1997. It ended with the overthrow of President Mobutu.

<sup>12</sup>In Shabunda, an administrative division in Sud-Kivu part of this study, the Raia-Mutombokis control 95% of the territory. See for instance <http://radiookapi.net/actualite/2013/02/28/shabunda-la-milice-raia-mutomboki-occupe-95-du-territoire-selon-son-administrateur/>.

<sup>13</sup>See <http://www.bbc.com/news/world-africa-19651888> , <http://radiookapi.net/actualite/2012/08/07/nord-kivu-le-m23-installe-progressivement-son-administration-locale-rutshuru-2/>

<sup>14</sup>For an overview of recent Congolese history, see the following historical accounts: Clark (2002), Nest (2011), Nest, Grignon, and Kisangani (2011), Ngonzola-Ntalaja (2002), Stearns (2011), Vlassenroot and Huggins (2005), Vlassenroot and Raeymaekers (2004), Van Reybrouck (2008), Autesserre (2006), Autesserre (2007), Autesserre (2008), Verweijen (2013).

## 2.2 The mining sector

Despite their interests were originally political, armed groups mostly discovered the economic value of violence at the start the Second Congo War, and these interests persisted during the post-conflict period. One of their major sources of revenues is the taxation of mineral trade.

Mineral extraction in Eastern Congo is labor intensive and is a major livelihood of the local population. The World Bank (2008) estimates there are between five hundred thousands and two million artisanal miners in DRC who are responsible for 90 % of DRC mineral production. Heavy minerals, with high real productivity of labor, coltan and cassiterite, coexist with lighter minerals, gold, which are harder to find. So-called artisanal mining requires minimal capital and skills. Miners of heavy minerals hand over bags of fifty kilograms of output to carriers, who walk to the closest village. Transportation to the closest village (henceforth, support village) can take up to multiple days on foot. Owing to the large volumes produced and a poor road infrastructure, traders ship heavy minerals from the support village to Bukavu and Goma by plane. Economic activity up to the support village is vulnerable to expropriations, so armed groups provide security along the route and at the mine in exchange for taxes (Nest, 2011, Verweijen, 2013). Gold output, in contrast, is easy to conceal. Because of its large value to weight ratio, gold miners often conceal the gold they are able to find. Miners and traders circumvent taxes by smuggling gold directly through Burundi, Bukavu, or Uvira, and Congolese border customs. According to World Bank (2008) estimates, the value of gold exports is US\$125 million, most of which is smuggled. Across minerals, armed groups often provide security and collect taxes at the mine as well as on other economic activity at the support village.<sup>15</sup>

Property rights are generated in a pluralistic legal environment. Formal law and traditional law co-exist, often with contradictory property rights.<sup>16</sup> Non-state armed actors, and to a lesser extent state agencies in areas controlled by the state, claim rights to tax mining output. Despite the apparently chaotic distribution of rights, the production process is tightly organized in a well-defined hierarchy, where miners are partial residual claimants. Since production is labor intensive, armed groups rarely mine themselves. Instead, to acquire resources, they most often tax output

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<sup>15</sup>The average world price per kilogram of gold in the period was US\$17,404, compared with US\$136 for coltan. Daily production per worker is approximately 20 kg in coltan, and between 1 and 10 grams in gold. See De Faily (2001), De Koning (2009), Nest (2011), Geenen (2013) and Vlassenroot and Raeymaekers (2004) for descriptions of the mineral sector and the role of armed groups.

<sup>16</sup>Traditional (customary) law is the legal system practiced by local Chiefs, which is justified on local customs. According to customary law, the village chief is the ultimate authority in the village and owner of the land.



produced by voluntary mineral workers.<sup>17</sup> Taxes are common knowledge, and armed groups often cooperate with the population by offering protection to entire communities in exchange for taxes.

In the period for which I have data, the mining sector was affected by two price shocks. First, at the start of 2000, Sony announced the Christmas release of its new Playstation product, which is built with processed columbite-tantalite (named coltan in the DRC). At the time of the Playstation announcement, most columbite-tantalite was mined in Australia and its supply was inelastic because of large fixed costs in the production process. In response to the announcement, columbite-tantalite processing firms rushed for columbite-tantalite from other areas, leading the daily price of columbite-tantalite to skyrocket in 2000 from \$90 per kilogram to \$590 per kilogram. The DRC emerged as a major substitute of Australia's columbite-tantalite. Second, following September 11<sup>th</sup> and the economic downturn, investors sought safe assets, which included gold. The price of gold rose in the aftermath of the 2002 crisis and continued to rise during the post-conflict period (2004-2013). Figures 1 and 2 show the world prices of gold and coltan.<sup>18</sup>

### 3 Organized crime and state formation

#### 3.1 What do states do?

“If protection rackets represent organized crime at its smoothest, then war making and state making - quintessential protection rackets with the advantage of legitimacy - qualify as our largest examples of organized crime. [...] There is of course, a difference, racketeers operate without the sanctity of governments. [...] Governments stand out from other organizations by their tendency to monopolize the concentrated means of violence. The distinction between legitimate and illegitimate force, furthermore, makes no difference to the fact. If we take legitimacy to depend on conformity to an abstract principle, or on the assent of the government, these conditions may serve to justify, perhaps even to explain, the tendency to monopolize force; they do not contradict the fact.”<sup>19</sup>

In contrast to the view that states emerge from organized crime, popular conceptualizations of

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<sup>17</sup>Slavery is rarely observed, even by the miners themselves, except in a few well documented isolated cases (United Nations Security Council, 2002). Furthermore, the data collected suggests miners' income is much higher than agricultural income, consistent with the hypothesis that miners are free labor. It is nonetheless possible that other subtle forms of coercion are in place, such as prohibitive debt contracts.

<sup>18</sup>See Nest (2011), Stearns (2011), and United Nations Security Council (2002).

<sup>19</sup>Tilly (1985).

the state, including some prominent scholarship, examine states mostly through their legal status in the international system of recognized states (Mamphilly, 2011). As a result of this choice of definition, such view fails to recognize that states emerge from, and are, coercion wielding organizations before they are even recognized as a “legitimate” entity in the international system by the international community - an outcome of global politics. This proposed reasoning ignores the underlying social process of evolution leading to the emergence, or failure, of states as we know them today.<sup>20</sup> This social process is the focus of the current paper, as well as of voluminous scholarship in anthropology, sociology, and economics, which studies the origins of primitive or “Early states” from coercive domination, their organization (Carneiro, 1970, Claessen and Skalnik, 1978, Claessen and Van de Velde, 1991, Marcus and Flannery, 1996, Skaperdas and Syropoulos, 1995), and also, but not only, their evolution towards modern states (Ardant, 1975, Tilly, 1985, 1990). While Tilly (1985, 1990) studies mostly the creation of modern European national states, his contribution to define the nature of the state expands nevertheless to the study of state formation in different periods of history. This so-called organizational view of the state permeates the sociological, anthropological, and political science studies of the state: the state is an organization that owns the monopoly (or quasi) of “legitimate” violence in a given territory (Weber, 1946).<sup>21</sup> I next present the basic elements of existing studies of state formation, with a focus on the anthropological literature on the formation of Early (pristine) states (Claessen and Skalnik, 1978).

In the form of war, repeated conquests, tribute, and taxation, the first stages of the state (and as a matter of fact, long subsequent periods) were coercive.<sup>22</sup> They often gave rise through unusually high levels of violence.<sup>23</sup> State formation was the process of coercive domination from one group over another for the extraction of a surplus through tribute and taxation - often armed

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<sup>20</sup> “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.”

<sup>21</sup> The coercive definition of the state predates Weber (1946). Trotsky (1905) wrote in 1905: “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.”

<sup>22</sup> See Claessen and Van de Velde (1991), Chapters 3,4,5,10 for examples of this pattern.

<sup>23</sup> “The trimmed-down 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 organised crime. War makes states [...]” (Tilly, 1985).

nomads on pastoralists, or dominant class over the majority of the population (Carneiro, 1970, Chrétien, 1987, Claessen and Skalnik, 1978, Keeley, 1996). If the extraction of a surplus motivated the formation of Early states, the availability of such surplus, and the ability to extract it, were likely fundamental determinants of the formation of states, and the different trajectories they took.<sup>24</sup> Following this extractive logic, Carneiro (1970) exploits data from all recorded Early states, and argues that the outside option of the population — the ability to escape domination to productive land — determined how much surplus the coercion-yielding organizations aiming to establish domination could extract from them. This thus explains whether such coercive organizations established Early states in a particular territory, or instead failed — an argument known as the circumscription theory. The essential feature of states is that they introduce coercion to transform the organization of redistribution in society. They replace Chiefdoms, where resources are redistributed through reciprocal gift-exchange relationships between rulers and the population, and prestige goods, which sustain the superiority and legitimacy of Chiefs. States' distinctive feature is that the ruling organization has enough coercive power that coercion substitutes for social relations of reciprocity between the ruler and the donee.<sup>25</sup>

While popular views require that, to be considered a state, the coercion-wielding organization must produce legitimate violence, the anthropological evidence instead reflects the challenges of the process of legitimation by Early states. Newly formed pristine states went at length to obtain voluntary compliance by attempting to create ideological, religious, and ritualistic foundations to the inevitability of their rule - whose foundations were in fact coercive.<sup>26</sup> Pristine states struggled to create legitimacy, often making efforts to subvert local, traditional pre-existing forms of legitimacy and beliefs in order to create their own, often without succeeding — “inchoate” states being the exemplary form of Early states which struggled to obtain legitimacy.<sup>27</sup> Not only was legitimacy rarely attained, it is also a redundant implication of the successful concentration of the means that produce coercion. In the minimalist view of legitimacy, “legitimacy is the probability

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<sup>24</sup>“Accumulation of income by the state is crucial; if not available in sufficient quantities, the polity will decline or even collapse. Accumulation can be extended in several ways: by expanding the internal production, by preying on weaker polities, or by seeking additional resources through trade and gifts.” (Claessen and Van de Velde, 1991).

<sup>25</sup>See Claessen and Van de Velde (1991), Marcus and Flannery (1996), Mauss (1970), Sahlin (1965). The role of prestige goods is well-documented, especially for the Kingdom of Kongo. See (Ekholm, 1977, Thornton, 1983).

<sup>26</sup>See, for instance, Claessen and Skalnik (1978), Claessen and Van de Velde (1991). Claessen and Skalnik (1978) document, for instance, that in order to provide ideological foundations to their rule, Carolingians had to incur exorbitant costs, engage in endless wars of conquest, in an attempt to obtain the sacrality by the Church, and take it away from the Merovingians.

<sup>27</sup>Claessen (1990) and Toland (1987) describe how the Inca state had often nonexistent legitimacy among the subjugated peoples.

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). Thus, while the process (and struggles) to legitimate the authority of early states permeates the historical evidence, the success at creating legitimate authority as characteristic of states lacks empirical relevance — even to understand the behavior of today’s states, many of which lack legitimate authority.<sup>28</sup>

Turning to the impact of states on welfare, the historical and anthropological literature are inconclusive. In theory, organizing violence under a violence monopolist improves welfare over anarchy (Grossman, 1999, Hirshleifer, 1995). In reality, states often offered protection against their own violence, creating protection rackets. When anarchy is not the relevant counter-factual to state formation, the distortionary effects of expropriation by states, and the dis-utility created by coercion, could well have decreased welfare of the population over the counter-factual.<sup>29</sup> Furthermore, even if states increased the surplus that the economies under their control could generate, the population may not have immediately benefited from it as most may have been extracted by the state through tribute and taxation. How such surplus is shared requires considering the relative bargaining power of the population and the state, and has been the subject of extensive scholarship in the study of subsequent transformation into modern states (Greif, 2008, Tilly, 1990).<sup>30</sup> This later phase is not the focus of this paper.

A distinctive feature of states that emerges from the existing scholarship is that the formation of states imply a fundamental transformation over pre-existing forms of government (often traditional Chieftdoms). They introduce coercion to the field governance, substituting enforcement of property rights based on social institutions (such as the institution described in Greif (1993)), and monopolizing the means of coercion in society in the hands of one, more or less cohesive, organization. States are to government what markets are to the economy: they introduce the possibility of compliance under the threat of coercion, lifting the requirement of relationships or

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<sup>28</sup>In this view, the belief itself that states emerged first from legitimate demands is rather the outcome of successful legitimation by the state than an accurate representation of the historical evidence (Tilly, 1985).

<sup>29</sup>Evidence of this is the extent of forced labor and the high levels of tribute and coercion by Early states (Keeley, 1996).

<sup>30</sup>For instance, Tilly (1990) argues that the need of rulers to draft population for military service, to hire them for the growing state administration as a result of the creation of direct rule, or the states’ borrowing needs, created bargaining power of the citizens, especially merchants and capitalists; this change in bargaining power likely had an impact on the distribution of such surplus between rulers and citizens: power, and resources, had to be negotiated. “Power holders’ pursuit of war involved them willy-nilly in the extraction of resources for war making from the populations over which they had control and in the promotion of capital accumulation by those who could help them borrow and buy.”

reputation to incentivize compliance, thus expanding the attainable surplus. For the purpose of this paper, states are thus an organization that defines (stable) property rights through coercion. The creation of states is, in fact, the emergence of property rights over the surplus of an entire economy, an application of Demsetz (1967) to an entire economy — the more surplus there is to tax, the more likely will be property rights over such total surplus to emerge. Such property was historically enforced by stationary bandits, and states, through coercion against competing appropriation by other, internal or external, armed organizations.<sup>31</sup>

## 3.2 Overarching question

This paper aims to provide an answer to the following questions: Under what circumstances are states more likely to emerge? What forms are taken by states and what determines such forms? What determines the persistence of the state?<sup>32</sup> In light of the previous discussion, the state-like trajectories taken by organized crime appear to offer a suited environment to study the trajectories of (pristine) state formation. Armed bandits and armed groups belong to "the continuum [that] ran from bandits and pirates to kings."<sup>33</sup>

The case of the Nduma Defense of Congo-R provides a useful motivating example.<sup>34</sup> The armed group, formed of 1468 combattants, controled as of April 2015 an area of 91 villages. In each village the group collects monthly poll taxes from households, and weekly agricultural output taxes (in kind). To collect poll taxes, the group conducts a village census in each village, and enlists village Chiefs to collect the poll tax for them: the Chiefs receive a fixed amount of tax tokens corresponding to the village size. Chiefs distribute tokens among the households in their village in exchange for the poll tax. The group administrators inspect the tax revenues and tokens among households, and Chiefs who fail to fulfill their monthly obligation are sanctioned in public. The group also collects a VAT on traded merchandise, whose rate they proudly compare to the Congolese state's higher rate. In addition to tax revenues, the group also enforces a monopoly of beer, liquors and

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<sup>31</sup>The allocation of property rights matters precisely because armed actors cannot commit not to expropriate, creating a common pool problem in the absence of states - a failure of the political Coase theorem.

<sup>32</sup>The overarching questions in this section follow Tilly (1985).

<sup>33</sup>"The continuum ran from bandits and pirates to kings via tax collectors, regional power holders, and professional soldiers." (Tilly, 1990)

<sup>34</sup>The argument made in this paper hinges on extensive qualitative research spanning from 2010 to 2015, and includes conversations with commanders, generals, colonels, and combatants of the following (active and inactive) armed groups: Nduma Defense of Congo-Sheka, Nduma Defense of Congo-Guido, Mayi-Mayi Padiri, Mayi-Mayi Yakutumba, Mayi-Mayi Kifufua, Mai-Mai Nyakiliba, Raia Mutomboki, Mayi-Mayi Uvira, M23, Mayi-Mayi AP-CLS, AFDL.

cigarette distribution in their territory. They ship alcohol and cigarettes from Goma and resell them locally, keeping the surplus.<sup>35</sup> The group also administers justice. They have created a code, where, among other disorderly behaviors, rape is heavily sanctioned by publicly inflicted violence. They operate with a well-fledged three tier administration, where commander T1 is the main administrator and every village has a delegate administrator, responsible for enforcing tax collection and the sale of alcohol and cigarettes. The group also has an intelligence officer, who, in addition from obtaining information from rival groups, plays mostly the role of investigating tax evasion. The administration also has an officer responsible for relationships with civilians, and an officer for group supplies. As of August 2015, the group had the capacity to project considerable violence: they owned 925 AK7, 3 RPG's, 2 mortars, and 7 machine guns. The group has its own logo, anthem, and the documents they produce and seal in their territory carry legal weight for the population. The group also uses spiritual invocation to legitimize the rule of their general — in addition to activating magical beliefs about bullet proofness and military “technologies”, the general is the group member who establishes the communication with the ancestors. While this group is unusually large, Eastern Congo in the period studied by this paper had more than 60 different armed groups, in a continuum from individual bandits to better organized structures as the one described here that occupied larger territory.

To study answer the overarching questions on state formation, this paper thus looks for a movement along this continuum from bandits to states, and searches for the emergence of the essential functions of the state among coercion-wielding organizations — independently, for now, of whether such entities will later survive or perish, but nevertheless examining the determinants of survival's length. Stationary bandits are an emerging form of coercive organization that embeds distinctive state-like features, not embedded by petty criminals. These are usually summarized to: war making (eliminating external rivals), state making (oppressing internal opponents), protection (oppressing the threats to the property of those who they govern), extraction (designing the above means to finance the above activities).<sup>36</sup> Stationary bandits, facing the same trade-offs, naturally solve the problem of the representative (pristine) state - they collect revenues through coercive taxation, they need to gain the support of the population, they are specialists in violence and protection, and they need to eliminate internal and external enemies. Different trajectories

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<sup>35</sup>I had access to their records, which indicate that every month, they make on average 5,644 USD of revenues from beer, 5,173 USD of revenues from liquor, and 12,666 USD of revenues from the sale of cigarettes.

<sup>36</sup>Tilly (1985)

of states-in-the-making may emerge from stationary bandits facing different constraints.

This paper does not aim at proving that stationary bandits “are” states. Instead, it is concerned with the conditions under which the properties of a location induce armed actors to develop more state-like institutions, or instead act as petty criminals in the same, or other locations. It is not necessary for the argument of the paper to observe “states”. It is not necessary, because it will be sufficient to look for the emergence of stationary bandits: they embed the original form of states, before they are even considered by the international system, and they are confronted with the same problem to solve. Arguing that the emergence, and trajectories, of stationary bandits can inform us about the state formation process along the continuum that runs from bandits to Kings thus does not require to observe states as we know them today, modern nation states — it will be sufficient to examine coercion-wielding organizations that embed all, or most, features of pristine states and other states-in-the-making that survived or not. Characterizing coercion-wielding organizations as states, or as intentionally creating future states, would also be misleading. Referring to them as states is misleading, because popular views of the state hinge on the welfare nation state, a recent, yet anomalous form of the state, and often expect monopolies of violence to be recognized as a legitimate entity in the international system before they can be called states — ignoring the majority of states-in-the making, which perished, and whose experience is less well documented. However, the creation of nation states is a late development of the historical process, and is the focus of Tilly (1990). The creation of the welfare state arises even later, in the 20th century. Thus, attempting to prove that stationary bandits are states would be a lost battle: proponents of the popular view would oppose their relevance, yet ignoring a long process of tens of thousands of years in which human groups developed political structures based on coercion, extraction, and protection, before such structures were recognized as legitimate entities in an international state system or even developed its modern form of the welfare nation state. Finally, it would be a common teleological mistake that runs contrary to historical evidence to narrow the search for the process of state formation to experiences where the creation of the modern nation state is the end goal, or the natural future outcome of the process; states, in their varied forms, were mostly accidental outcomes of the logic of coercive extraction.<sup>3738</sup>

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<sup>37</sup> “War making, extraction, and capital accumulation interacted to shape European state making. 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).

<sup>38</sup> A related question is whether stationary bandits embed features of empires. “For a state to become an empire, it must incorporate people of other languages and ethnic groups.” (Marcus and Flannery, 1996) Hence, to the extent

I organize the paper along the following dominant themes in the literature of state formation: organization of violence, organization of revenues, provision of security, provision of justice, administration, legitimation, and welfare (Claessen and Skalník, 1978).

Organization of violence. In the absence of a functioning state, violence may be disorganized, as in anarchy (Bates, Greif, and Singh, 2002, Grossman, 1999, Hirshleifer, 1995). Stationary bandits, like a state, create a (quasi) monopoly of violence in the territory they control, excluding internal enemies and internalizing the value of protection through the channel of their own extraction. Because stationary bandits stay relatively longer periods of time than petty bandits can afford to, they are also inter-temporal residual claimants of their own expropriation. This gives stationary bandits a stable, distinctive feature that petty criminals do not have. Note that, while states-in-the-making organize violence, they often acquire territorial control through high levels of violence, especially if they faced resistance by subjugated peoples — wars of conquest.<sup>39</sup> This paper thus begins by examining the *circumstances* under which stationary bandits emerge in particular locations — beyond a location choice, the decision to organize violence rather than remain a petty criminal, conditional on a given location choice — as well as the *conditions* in which they do so — whether by increases in violence (conquest) or by peaceful bargains (what Marcus and Flannery (1996) refers to as colonization).

Organization of revenues. While petty bandits maximize their static revenues after production decisions have been made by households and firms - hence aiming to capture 100% of the value of output - stationary bandits, like states, instead have a long horizon. The long horizon allows them to sustain a credible commitment to a tax plan, leading to the emergence of taxation. Taxation is always under the threat of coercion, but a fundamental difference is that taxation is anticipated when households and firms make decisions, which allows the stationary bandit to select lower levels of extraction than 100% to maximize their revenues (or any other social welfare function they ought to maximize) - leading, hence, to optimal taxation. Taxation, as tribute, is

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that these organizations do take over villages and sites that are not necessarily their ethnic groups, they may also confront similar governance trade-offs as empires do. This is the scope of ongoing research and is beyond the scope of this paper.

<sup>39</sup>The limitations of archaeological evidence to document battles makes it difficult to generalize about the formation of Early state by conquests. Marcus and Flannery (1996) explain “even in regions subdued by force it might require incredible luck to find archaeological evidence for a battle.” and “Not every province incorporated by an expanding kingdom must be taken by force. [...] Small polities, seeing that resistance would be futile, may accept a facesaving offer. Larger polities, unwilling to lose their autonomy, may have to be subdued militarily.” This underscores the value of the approach presented in this paper to observe the evolution of violence alongside states-in-the-making.



distinct from petty theft in that it reflects an underlying implicit contract between armed actors and households, and is known to households when they make their investments. I thus look for the emergence of taxation as a key distinctive feature of states-in-the-making.

Provision of security. If stationary bandits solve a similar problem than states, they should aim at providing security of property rights. Independently of the motivations that lead stationary bandits to provide public goods in general (see legitimation below), the stationary bandit is a residual claimant of output in his location, hence internalizes the welfare costs associated with insecure property rights. He should aim at protecting the workers against expropriation by other bandits — but also against contestation of its own authority by outside groups. I thus examine the provision of security in the sites they control.

Provision of justice. If stationary bandits, like states, internalize the outcome of workers' investment through the channel of taxation, they will be tempted to use their comparative advantage in coercion to provide a credible contract enforcement environment. In the absence of the stationary bandit, contracts are usually enforced through social institutions that hinge on collective reputation, as in (Greif, 1993), and they are often arbitrated by a traditional Chief who lacks the means of coercion but enjoys legitimacy (Claessen and Skalník, 1978, Vlassenroot and Raeymaekers, 2004). This type of contract enforcement is usually less efficient than third-party contract enforcement through the threat of coercion. Hence, like states, stationary bandits should be tempted to provide an administration of justice and dispute resolution that is credible.<sup>40</sup> I thus examine the centralization of dispute-resolution mechanisms in the hands of stationary bandits, away from traditional institutions of justice.

Administration. Like states, stationary bandits may need to create an administration in order to implement their desired policy and tax collection. In cases where taxation is straightforward to implement and evasion is impossible, such as an output tax at the exit of a well-defined production site for output that cannot be evade taxation, the return to creating an administration is low — such as the well-documented case of the light administration needed in England in response to the prevalence of easy to tax international trade (Ardant, 1975). In locations where the taxable base is difficult to observe, for instance, the returns to invest in a (costly) administrative and fiscal apparatus will be higher — conditional on a stationary bandit finding it worth to concentrate the

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<sup>40</sup>In addition to the incentives to administer justice because of the taxation revenues that stable property rights may provide, bandits may also do so for profit as a private service, as the Sicilian mafia, for instance (Gambetta, 1993).

means of violence in such location. When the value of such difficult-to-tax tax base increases, the return to creating a fiscal administration will naturally disproportionately increase, due to the higher value of forgone tax revenues — such as the well-documented case of the heavy administration needed in corresponding France (Ardant, 1975). I thus observe the creation of administration by stationary bandits, and the extent to which they create direct rule.

Legitimation. Stationary bandits, like states, need to obtain the voluntary assent of the population. While often lacking legitimacy (such as “inchoate” pristine states) pristine states are often described as providing efforts at legitimation, as an ongoing process - not an outcome (Claessen and Skalnik, 1978). The stationary bandits face the same problem. If they govern a population against the will of the population, they are more likely to face subversive internal threats, non-compliance, and potentially collusion between the population and potential external contenders. To improve the population’s support, like pristine states, stationary bandits may use myths and religion. They may also invest in public goods and create the perception that they are charging a tax in exchange for protection against external threats — which they may themselves create in the case of protection rackets as in the history of state formation. It would be misguided to rule out the relevance of stationary bandits on the basis that the “legitimate” state is the Congo. As a matter of fact, the population in many areas of Eastern Congo very often does not even recognize the Congolese state as a legitimate ruling organization (Sanchez de la Sierra, 2014). I thus examine the provision of public goods, the perception of protection from the lens of the households, and the support for the group by households — as evidenced by households’ conversations in private about groups that no longer exist.

Welfare. The literature on state formation is inconclusive about the welfare gains of the governed population (Claessen and Skalnik, 1978). There is evidence that before violence is organized by pristine states or stationary bandits, the aggregate levels of violence were likely much higher (Keeley, 1996), and anarchy is known to have drastic welfare consequences through the disincentives to invest it generates (Bates, Greif, and Singh, 2002, Hobbes, 1651).<sup>41</sup> However, a state-in-the-making, much like a stationary bandit, may unambiguously decrease aggregate welfare through distortionary taxes in the case of protection rackets, where counter-factual insecurity

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<sup>41</sup> “In such condition there is no place for industry, because the fruit thereof is uncertain, and consequently, not culture of the earth, no navigation, nor the use of commodities that may be imported by sea, no commodious building, no instruments of moving and removing such things as require much force, no knowledge of the face of the earth, 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.” (Hobbes, 1651)

is mostly generated by himself as a threat. Furthermore, increase in the aggregate surplus needs not translate into increases in welfare by the average households, since the surplus may just be extracted by the stationary bandit to sustain himself and a selected elite, exactly as pristine states did. Despite the fact that there is no consensus as to whether emerging states had a positive impact on welfare, it is valuable to understand the extend to which, and the conditions under which, the emergence of monopolies of violence impacts welfare. I thus examine the evolution of production, and consumption, with and without stationary bandits.

Having presented the overarching question, I next provide an economic theory for when stationary bandits, and taxation, are more likely to emerge.

## 4 A simple model of stationary bandits

In this section I present a model in which a violent actor can acquire resources from households. The objective of the model is to show that global demand for output produced in a given location, and the physical properties of local production determine the value of holding a monopoly of violence in that location. The model applies established results of optimal taxation to the decision to form monopolies of violence and has a similar setup to Besley and Persson (2013).<sup>42</sup>

Anecdotal observation dictates the following modeling choices. First, the model considers taxes on labor inputs and mining outputs. In reality violent actors levy taxes on mineral output, mining labor inputs, food sales, transit of persons, village mills, as well as poll taxes (Sanchez de la Sierra, 2014). I focus on labor taxes and output taxes for parsimony, and because they capture that when there are multiple margins of tax evasion, the optimal tax vector is, in general, a tax on the multiple margins. Second, the model separates expropriation in the form of (uncoordinated) pillage, and organized expropriation under a long-term monopoly of violence, with commitment to an expropriation plan (taxation). This distinction reflects the anecdotal observation of the behavior of violent actors in Eastern Congo. In the model, I endogenize the form of expropriation. Of 546 recorded violent events in the sample villages, 56% are pillage operations, aimed at capturing village assets. Another 38% are conquest attempts, aimed at gaining the monopoly of violence in a village. Monopolies of violence in the sample most often tax, but rarely pillage their

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<sup>42</sup>Tax base elasticity in this model can capture mobility of factors of production, emphasized in Bates, Ndulu, O'Connell, Collier, and Soludo (2008), Herbst (2011), Scott (2009) and Bates and Lien (1985).

households.<sup>43</sup> Section A in the Appendix provides the mathematical foundations of the following testable implications:

Testable implication 1: A rise in the price of coltan leads to new monopolies of violence, taxation, conquest attempts.

Testable implication 2: A rise in the price of coltan leads to monopolies of violence, conquest attempts *more so in coltan villages near airports*.

Testable implication 3: A unitary rise in the price of coltan leads to monopolies of violence, conquest attempts *more so than a unitary rise in the price of gold does in a gold village*.<sup>44</sup>

Testable implication 4: Demand for coltan leads to “minimalist states”, because stationary bandits need very basic infrastructure to collect taxes on output and trade — analogous to the case of England (Ardant, 1975). Demand for gold will increase the profitability of creating a monopoly of violence in gold sites disproportionately less — or not at all — but it increases the returns to develop a fiscal administration, among stationary bandits who are controlling gold sites — analogous to the case of France (Ardant, 1975).

## 5 The data

This section describes the data collection, and presents the main variables used in this paper.

### 5.1 Data collection

I organized the collection of yearly historical data of 380 settlements of Eastern Congo by eleven surveyors, in order to map all (feasible) coltan sites and, within each administrative division (Territoire), a random sample of gold sites of the Province of Sud Kivu. The design of the data collection project reflects the structure of the mining sector. Each mining settlement (henceforth, mining site) is attached to a support village. A support village is defined as the village in which land the mine is located. In practice, the support village is the closest village to the mining site.

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<sup>43</sup>Figure 12 in the online appendix provides empirical support to the distinction between conquests and pillages. The figure shows that conquests occur early in the morning, possibly to surprise the defense force, and pillage operations take place at sunset, consistent with a crime deterrence hypothesis (Becker, 1968).

<sup>44</sup>The effect of price shocks on pillages is ambiguous. While a higher price increases the rents in a taxation relational contract, in the presence of multiple contenders it also increases the probability of termination, increasing the temptation to pillage. For taxation, this effect is less important because as the price rises, stronger bandits better able to secure continuation replace weaker bandits.

The average distance between a mine and its support village in the sample is 10 walking hours, with a maximum of 180 hours. Each support village can have multiple mining sites, but each mining site is only attached to one support village. Since the economic incentives of stationary bandits are most likely to be affected by changes in global mineral demand at the mining sites themselves than at the support villages, the surveyors reconstructed the history of every mining site (as well as of every support village). Due to security and logistical challenges, the surveyors activities took place at the support village. This strategy was feasible because the entire population and authorities of support villages are involved in mining activities at the mining sites, even if workers often live at the sites themselves.<sup>45</sup> There are 380 sites, of which 113 “support villages”, 237 mining sites and 20 pure agricultural villages. Figure 5 maps the villages in the sample based on their endowment of minerals.<sup>46</sup> The data collection protocol contemplates the following data collection design in 7 days in each village to reduce measurement error and strategic mis-reporting of information.

First, the surveyors identify a group of “history specialists” on the first day in the support village. In practice, the history specialists are individuals who best master the relevant history. Surveyors could identify them easily due to their involvement in the mining sector as well as to the local tradition of oral history. History specialists are often village chiefs, village elders, mining sector experts, including traders and miners. Surveyors then train the history specialists on how to collect historical data. In each subsequent day, the surveyors monitor how the history specialists collect data. In the last day in each village the surveyors hold a day-long meeting with the history specialists, where they confront the data gathered from the different sources. The data from this meeting is the main source of data used in this paper. Second, to address the possibility of recall error and systematic reporting bias by the history specialists, the surveyors implement 8 household surveys in private during the 7 days. In each household survey, they reconstruct the history of the village during a 4 hours discussion. Third, the survey implemented during the day-long interview with the history specialists at the end of the village visit has multiple sources for key variables, which I use as cross-validation. Fourth, the surveyors implement an exhaustive set of time cues to reduce measurement error associated with years (de Nicola and Gine, 2012).

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<sup>45</sup>I account for urbanization in the analysis using detailed data on economic activities at the mining site.

<sup>46</sup>I sampled all coltan support villages and their mining sites. Since gold villages are far more numerous, due to budgetary constraints, I selected a random sample of gold villages within blocks defined by administrative division (Territoire). I also sampled 20 agricultural villages by matching agricultural villages to mining villages within one administrative division, based on all geographic characteristics known ex-ante. To sample agricultural villages, I minimized the Mahalanobis metric between mining and agricultural villages. See Rubin and Stuart (2007) for matching at design.

Surveyors use common knowledge regional events as a reference to locate the events reported by the respondents in time. Anecdotal evidence suggests this strategy was very effective at identifying years with little or no uncertainty. Fifth, survey questions focus on transitions and events easy to memorize.<sup>47</sup> Sixth, surveyors draft a qualitative report in each village, where they describe the history of the village, all groups that held a monopoly of violence, their activities and their motivations. To draft these reports, surveyors use the information acquired in the different surveys, as well as additional in-depth interviews with combatants, ex-combatants, and other civilians.<sup>48</sup>

By the end of the week, the surveyors were confident they had recovered the history of the village. I use the information in the 8 household surveys, the multiple of sources of information embedded in the village survey, and the qualitative reports, to cross-validate each year\*village observation. Section 8.1 compares the resulting data to other sources.

## 5.2 Measurement

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

I identified the villages endowed with minerals in existing datasets (International Peace Information Service, 2009) and complemented it with one week of exploratory work by the surveyors in each lower level administrative division in collaboration with the miners, authorities, and mineral traders. For the entire analysis, the mineral endowment indicates whether a site had available mineral deposits of a given type at any time in the past. While this approach to measure mineral endowments can bias my estimates downwards, it allows me to circumvent the fact that mining output is endogenous. Furthermore, I do not record exhaustion of minerals in the sample. Figure 1 shows the US prices of gold and coltan. I define a stationary bandit as an armed actor who holds the monopoly of violence in a given site for at least 6 months. Stationary bandits are most frequently alone when they occupy a site. Stationary bandits, which surveyors and villagers refer to as “organization of security” in the village, are a very common phenomenon in Eastern Congo. Villagers easily distinguish between stationary bandits and roving bandits. *Conquest attempts oc-*

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<sup>47</sup>For instance, there are two bags sizes for heavy minerals (50 kg and 75 kg). To measure output taxes, surveyors obtained the fee paid for each size of bag. I then compute the tax per kilogram based on these variables. To measure taxes on labor, surveyors recorded the daily fee miners paid at the entry of the mine for the right to work. These fees are relatively stable, which reduces measurement error. For this reason, certain variables had to be excluded from the mining site survey.

<sup>48</sup>In the reports, surveyors note explanations for patterns in the data and provide descriptions of how the bandits and civilians perceive their relationship. I use this information extensively in Sanchez de la Sierra (2014).

cur when a violent actor engages in violence with another armed group, with the aim of acquiring the monopoly of violence of the village. *Pillages* occur when a violent actor launches an attack on the village aimed *exclusively* at stealing assets. This definition reflects that local populations are able to distinguish the purpose of the attacks, due to sharp observable differences between pillages and conquests. In a *pillage*, armed groups usually arrive at sunset - when they are harder to monitor, and flee with the village assets within a narrow interval, often within 30 minutes. 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 pillage.<sup>49</sup>

With the geographic coordinates collected during the survey, I linked my data to geographical shapefiles I obtained from the Référentiel Géographique Commun.<sup>50</sup> 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.<sup>51</sup> As prices, I use yearly US prices of minerals reported from United States Geological Survey (2010).

Table 1 reports the summary statistics for 1999. Figure 3 shows armed groups' presence in the sample villages over the period. Figure 4 shows that stationary bandits collect stable taxes, provide protection and other public goods. The stationary bandits in the sample belong to 18 recognized armed macro-organizations. It is well documented that each of these organizations suffers severe discipline problems. Independent battalions controlling individual villages have a large margin to make decisions, some are even totally autonomous. The median stay of each stationary bandit, and the median length for a village without any stationary bandit, are both 4 years.

## 6 Empirical strategy

In this section, I present the econometric specification and potential threats to identification.

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<sup>49</sup>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.

<sup>50</sup>See Référentiel Géographique Commun (2010).

<sup>51</sup>The results are unchanged when I use the continuous measure.

## 6.1 Econometric specification

Estimating the effect of mineral prices poses a few challenges. First, local prices are endogenous and might reflect changes in supply. For instance, by exercising local monopoly power or depressing supply, armed groups might inflate local prices. Second, local prices are retrospective, and despite efforts to increase the quality of data collection, they might contain large measurement error. Bias from measurement error may be correlated across minerals or periods. I address this challenge by using the world prices around the time of well-documented global demand shocks.<sup>52</sup> To estimate the effect of (exogenous) world price shocks I use as my baseline specification a linear probability model, which allows a straightforward interpretation of the main interaction.<sup>53</sup> The dependent variable is a dummy indicating whether the mining site has a stationary bandit, whether there is taxation at the mining site, and whether there are battles between bandits for the control of the mining site. As main regressor I use the world price of coltan, interacted with a dummy indicating whether the site is endowed with coltan. All regressions include mining site and year fixed effects. Since the demand shock for coltan only occurs in the year 2000, including all years in the regression increases statistical power at the cost of introducing bias if changes to the US price are not exogenous in the remainder of the period. For that reason, I present the results using the whole period, then focus most analysis on the years 1999 and 2000, and add 1998 when adding time trends. In Section 7, I describe alternative specifications.

Table 1 shows that coltan and gold support villages are balanced on constant observable characteristics. Of 11 outcomes, only distance to a bridge in 2010, which is post-treatment, is significantly different across support villages with different mineral endowments.<sup>54</sup> Equation 1 presents

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<sup>52</sup>As a validity check on the relevance of the coltan shock, I collected economic data in the households surveys. The retrospective households' economic data reveals large economic effects of the mineral price shock. Figure 22 in the online appendix shows the results from the village survey for the annual number of marriages per village. Since marriage in the survey area requires the payment of a bride price, marriage is a normal good. The coltan shock drastically increased the number of celebrated marriages and led to large reallocation of labor to the mining sector. Second, nighttime satellite lights data confirm the evidence of the coltan shock. Figure 23 shows that a new bright town emerges in the year 2000 near Goma, the capital of the coltan province. This lighting is absent prior to 2000, and vanishes progressively in the following years. Henderson, Storeygard, and Weil (2011) introduced the nighttime data as a proxy for GDP. While not reported, this lighting is reflected in the provinces average stable lights. In addition, I computed zonal statistics of stable lights in each Province of the DRC and compared the change over time between coltan provinces and non-coltan provinces. The results show an increase in stable lights in 2000 in coltan Provinces, but remain constant in the remaining provinces. Finally, Figure 24 demonstrates that the survey identifies occupational transitions into mining in coltan support villages as a response to the coltan shock.

<sup>53</sup>The results using conditional logit are analogous. I report them in the online appendix.

<sup>54</sup>A probit of a dummy indicating coltan endowment on the geographic characteristics of the support village in 1999 has a log-likelihood ratio of 29.96, which is above the 95% of the reference Chi-squared distribution. However, joint significance is driven by distance to bridges: when I exclude distance to bridges from the specification, the



the baseline specification:

$$Y_{it} = \beta_t + \alpha_i + \gamma_c C_i p_{c,t}^{US} + X'_{it} \beta + \varepsilon_{it} \quad (1)$$

where  $Y_{it}$  is a dummy indicating the presence of a stationary bandit, occurrence of an attack, or taxation by armed actors at mining site  $i$  in year  $t$ . The term  $\alpha_i$  indicates mining site fixed effect,  $\beta_t$  indicates year  $t$  fixed effect, and when appropriate, I include  $X_{it}$ , a vector of site level time varying controls which I construct by interacting constant variables with year dummies. The variable  $C_i$  is a dummy for whether mining site  $i$  is endowed with coltan, and is constant over time,  $p_{c,t}^{US}$  is the logarithm of the price of coltan at year  $t$  in the US market, as recorded in United States Geological Survey (2010). The regressors  $p_{c,t}^{US}$  and  $C_i$  are collinear with the year and mining site fixed effects and I can thus ignore them. In all regressions including more than two periods, I cluster the standard errors at the level of the cluster of sites attached to the same support village.<sup>55</sup> Testable implication 1 implies  $\gamma_c > 0$ .

For each site, I obtain the shortest Euclidean distance of the support village of mining site  $i$  to an airport. There are 45 airports in the sample. To test implication 2, I include a dummy indicating whether the distance of the support village to its closest airport is above the sample median distance of support villages to their closest airport, and interact it with the main regressor,  $C_i p_{c,t}^{US}$ .<sup>56</sup> Equation 2 presents the specification for testable implication 2:

$$Y_{it} = \tilde{\beta}_t + \tilde{\alpha}_i + \tilde{\gamma}_c C_i p_{c,t}^{US} + \tilde{\gamma}_{ca} C_i p_{c,t}^{US} D_i^a + \tilde{\gamma}_{pa} p_{c,t}^{US} D_i^a + X'_{it} \tilde{\beta} + \tilde{\varepsilon}_{it} \quad (2)$$

where  $\tilde{\alpha}_i$  are mining site fixed effects, and  $\tilde{\beta}_t$  are the year fixed effects. The term  $D_i^a$  is a dummy indicating whether the shortest Euclidean distance of the support village of mining site  $i$  to an airport is above the median of shortest distances to any airport for all support villages in the sample. Testable implication 2 implies that  $\tilde{\gamma}_c > 0$  and  $\tilde{\gamma}_{ca} < 0$ . Finally, let  $G_i$  indicate site  $i$  endowment in gold and  $p(G)_t^{US}$  indicate the US price of gold at year  $t$ , and  $\gamma_g$  be the coefficient on  $G_i p(G)_t^{US}$ . Testable implication 3 implies  $\gamma_c > \gamma_g$ .

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likelihood ratio drops to 11.85, and I cannot reject the null that the coefficients on all explanatory variables are jointly not significant. I include only support villages since I did not collect GPS data on mining sites.

<sup>55</sup>When I use only two periods, I do not need to account for serial correlation because the treatment is assigned only in one period. In that case, I cluster the standard errors at the level of the cluster of sites\*year. The results are unchanged when I cluster at the cluster of sites. See Bertrand, Duflo, and Mullainathan (2004)

<sup>56</sup>The results are identical when I use the distance in kilometers.

## 6.2 Addressing potential biases in the econometric specification

The main concern to estimate  $\gamma_c$  is that the *timing* of the coltan shock may coincide with events that occur systematically in coltan mining sites for reasons unrelated to the price.

First, it is possible that the estimated coefficient picks up pre-existing differential time-trends in coltan mining sites instead of a causal effect of the coltan shock on armed actors' activity. I address this challenge in two ways. I first show the pre-existing trends using figures. I then include the year 1998 to the main specification, and estimate coltan specific linear trends.<sup>57</sup>

Second, since the coltan shock occurred during the Second Congo War (1998-2003), it is possible that the difference in armed actors' activity between coltan and gold sites is larger during the coltan shock than on average for other reasons than the shock. This can be the case if geographic characteristics correlate with coltan endowments and are related to the war but unrelated to the price shock. For instance, the Congolese Army is mostly present in period following 2004, and the effect of the Congolese Army presence might be to deter taxation of minerals by armed actors in coltan mining sites more so than other mining sites at the margin. The baseline specification focuses on the years 1999 and 2000 precisely to avoid this family of biases.<sup>58</sup>

Third, since the mining sites not endowed with coltan are mostly endowed with gold, it is possible that the estimated coefficient captures changes in the global demand for gold. To address this, I replicate the baseline specification including the US price of gold interacted with the endowments in gold. Between 1999 and 2000, the price of gold was stable, however.

Fourth, since the coltan shock occurred within an episode of war, the *sequence* of territorial conquest and armed groups' activity could reflect omitted variables that are correlated with mineral endowments. In particular, it is possible, that armed groups first conquered mining sites close to the road in 1998 and 1999, and that coltan tends to be found in mining sites further from roads.<sup>59</sup> To account for omitted geographic variables correlated with the sequence of territorial

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<sup>57</sup>With two periods a mineral specific linear trend is necessarily collinear with the treatment.

<sup>58</sup>In addition, in regressions on the whole period, I included controls in the specifications for the presence of the Congolese Army. To measure the presence of the Congolese Army, I use a dummy indicating whether to indicate if the army controls a given site in a given year. I also include the proportion of neighboring sites that are under the control of the Congolese Army in a given year. I operationalize "neighboring sites" by estimating the average number of sample sites in the same administrative division that are under the control of the Congolese Army, replicating this procedure for all levels of the administration. The results are unchanged and I do not report them in this manuscript because the Congolese Army is a "bad control".

<sup>59</sup>Another threat related to the sequence of conquest is that if a large number of gold mining sites are also endowed with coltan, the fact that the coltan shock precedes the gold shock may lead to conquest of gold mining sites - those endowed with coltan - and may thus lead to under-estimate the effect of the gold shock. This is not likely, since only 7 support villages have mines both coltan and gold sites.

control by armed actors, I control for distance to the road, time-invariant, interacted with year dummies, and replicate the exercise for distance to airports, bridges, parks, lakes, and main trading towns. I report only the results based on the interaction with distance to the road, results are unchanged when I use the other variables.<sup>60</sup>

Fifth, spatial clustering of coltan endowments and spatially correlated errors could give rise to the Moulton problem, and thus lead me to underestimate the relevant standard errors (Moulton, 1986). Underestimation of standard errors due to spatially correlated shocks, however, is implausible because mineral endowments are not spatially clustered, as shown in Figure 5. Spatial clustering of errors, thus, does not appear to be a threat to identification. Nevertheless, I account for the possibility of spatially correlated shocks in the main specification in this in three ways. First, I include region\*year fixed effects to the baseline specification in order to account for the possibility that coltan sites may be concentrated within a few regions and that the armed groups actions change in the year 2000 in those regions for reasons unrelated to the coltan demand shock, but which affect all mining sites in the region, including non-coltan mining sites. Second, I cluster the standard errors in all specifications at the level of the cluster of sites\*year (the cluster of mining sites attached to the same support village) or bucked at a higher level (cluster of sites, to account also for autocorrelation of prices and errors over time). Third, I recompute the p-value using randomization inference to account for spatial correlation.<sup>61</sup> If there is any spatial or temporal correlation structure in the data that could lead OLS to underestimate the standard errors, the distribution of coefficients estimated through randomization inference will have thicker tails and the real coefficient will be harder to distinguish from coefficients estimated using fake assignments to treatments.

Sixth, the coltan price may be autocorrelated. To account for this, in addition to accounting for autocorrelation of standard errors using clustering of errors at the level of the cluster of sites, I also implement a falsification test by including in the regression the lead of the main regressor,

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<sup>60</sup>Furthermore, as Table 1 shows, coltan and gold support villages are not distinguishable by any observable geographic characteristics, except for the distance to bridges in the year 2010 (post-treatment). It is therefore unlikely that any constant observed characteristic explains a different trajectory of stationary bandits independently of the demand shock.

<sup>61</sup>To implement randomization inference, I construct a reference distribution of coefficients that does not hinge on assuming normally distributed errors or on assumptions about the structure of the variance-covariance matrix (Gerber and Green, 2012). I do so in two ways, simulating 20,000 treatment assignments for each. In one set of simulations, I randomly re-assign US prices to years using the empirical vector of realized prices; in a second set of simulations, I randomly assign fake prices to years using a theoretical distribution. I use a uniform distribution with mean equal to the empirical mean of realized prices, but the result is not sensitive to the choice of the data generating process for prices.

as well as the lag of the main regressor. In addition, I use randomization inference to account for serial correlation in the errors.<sup>62</sup>

Seventh, the specification choice may bias the results. First, the linear probability model with fixed effects will produce biased estimates in the presence of errors in variables in the dependent variable (Hausman, 2001). Second, fixed effects estimates are usually sensitive to measurement error (Angrist and Pischke, 2009). I thus check whether the results are robust to alternative specifications. I first implement a regression with lagged dependent variable using Arellano-Bond dynamic panel GMM estimation, whereby I instrument for the first-differenced lagged dependent variable with its value the year before. I also replicate the baseline specification using conditional logistic regression instead and provide the results using additional specifications in the online appendix. I next discuss threats to identification of  $\gamma_c - \gamma_g$ .

First, the coltan and gold price shocks seem to be of different slopes. Price shocks of different slopes might generate very different responses by armed actors, for instance, if the armed actors' territorial conquest cost functions are non-linear. For instance, if engaging in conquest has a fixed cost, if there are liquidity constraints in the violence market, and if future prices are unknown, a steeper shock of equal magnitude could make conquest more profitable. However, the gold price rise is much larger in absolute numbers, it is thus unlikely that a positive difference is due to a steeper rise of the coltan price. I use the logarithm of prices in the regressions to examine the effects of percentual changes in price levels.

Second, the *timing* of the shocks may be correlated with omitted variables. For instance, following the Second Congo War in 2003, the Congolese Army progressively regains control, which coincides with the rise in the price of gold. If the Congolese Army is a deterrent of armed actors' activity,  $\widehat{\gamma_c - \gamma_g}$  will be biased upwards. To address this concern, I estimate the coefficient on the gold price for all possible year intervals in the sample, with and without controls for the nearby presence of the Congolese Army, and report the coefficients estimated with all feasible intervals. I implement this by generating all possible combinations of start and end dates such that the start date precedes the end date. I present the coltan coefficients using the same approach for comparison.

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<sup>62</sup>I do so by simulating 20,000 fake coltan endowments to the sample of mines and comparing the estimated coefficient using the real data to the distribution of estimated coefficients using the simulated endowments.

## 7 Results

I next estimate the effects of price shocks on stationary bandits, taxation, attacks, and persistence. The coltan shock leads armed actors to establish the monopoly of violence at coltan sites or fight for their control, and develop taxation contracts; this effect takes place especially near airports, where trade costs are not prohibitive; the effect of the gold demand shock is lower than the effect of the coltan demand shock. Figures 6 to 10 show the main results graphically.

### 7.1 Stationary bandits

Figure 6 shows the average number of stationary bandits per mining site for all years, for sites endowed with coltan and mining sites not endowed with coltan. Four observations are relevant. First, the coltan shock in the year 2000 led to a drastic increase in the average number of stationary bandits in coltan sites, from .45 to .82, compared to a rise from .45 to .55 in sites not endowed with coltan. Second, the trends preceding the coltan shock are identical in coltan and non-coltan mining sites. Third, the dynamics including all other years suggest that it is very unlikely that the differential increase in coltan in the year 2000 is due to intra-cluster correlation of shocks (shocks common to coltan sites) unrelated to the price shock. As is visible from Figure 6, the two times series are almost indistinguishable once the effect of the coltan shock is gone.<sup>63</sup> Finally, the dynamics of the times series suggest that there is persistence in stationary bandits, and thus that a short-term demand shock in the year 2000 had a persistent effects on institutions. I discuss persistence in Section 7.5.

I next turn to the econometric estimation of the effect of the coltan shock on stationary bandits. Table 2 shows the results from a linear probability model using mining site yearly data, with as dependent variable a dummy indicating whether a site has a stationary bandit. Column (1) presents the results where I included observations of the whole period (1998-2008) and a control for the US price of gold interacted with gold endowments at the site level. The estimation suggests that the coltan shock, a seven fold increase in the price of coltan, drove the probability of having a stationary bandit in a coltan site up by 47 percent. In contrast, the effect of the price of gold is

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<sup>63</sup>This is important because it is theoretically possible that coltan mining sites are systematically subject to common year shocks. While a structure of common shocks among sites endowed with the same mineral endowments is implausible due to the absence of spatial clustering by mineral endowment, economic networks could link sites endowed with the same minerals, creating the conditions for an intra-cluster correlation - where clusters are defined by mineral endowment and not by their location - that is significant in magnitude.

negative and insignificant, despite the fact that the price of gold was rising for the whole period and that Congo is considered a price taker in the global gold market. The rest of Table 2 presents the results aimed to address the concerns I introduced in Section 6.2.

First, since the coltan shock only took place in 2000, the price of coltan may not be exogenous when I use the whole period. Furthermore, using data from too many years around the coltan shock might understate the standard errors on the coefficient estimators (Bertrand, Duflo, and Mullainathan, 2004). To address this concern, Column (2), henceforth the baseline specification, replicates Column (1) using only the years 1999 and 2000 and excludes the gold interaction.<sup>64</sup> The main coefficient is unchanged.

Second, the sequence of conquest of coltan mining sites could reflect that coltan mining sites differ in constant characteristics, such as proximity to roads. For instance, armed groups may have first conquered sites close to the road in 1999, and then further sites in 2000. If coltan mining sites are systematically further from the road, the main coefficient could be biased. While differential trends by geographical characteristics correlated with the mineral endowment are implausible because coltan and gold support villages are balanced by distance to the road, I nevertheless account for this possibility. To control for time-varying effects of geographical characteristics, I use a dummy indicating whether the site cluster of mining sites is far from a road,  $D\ road_i$ , in Column (3). I define  $D\ road_i$  as the distance to the road above the 50th percentile in the sample. Column (3) replicates Column (2), adding the fully saturated model that includes all possible interactions with  $D\ road_i$ . When I include these controls, the main coefficient is even larger, despite the fact that the coefficient on  $pc^{US}\ D_i^a$  is positive and significant.

Third I estimate the effect of the coltan shock among sites that are close to an airport and the marginal effect for sites whose support village is far from an airport. I use a dummy indicating whether the support village is far from a local airport,  $D\ airport_i$ , defined as whether the distance of the support village to the closest road is above the 50th percentile of distances in the sample for all support villages. Column (4) replicates Column (2), adding the fully saturated model that includes all possible interactions with  $D\ airport_i$ . Consistent with testable implication 2, the main coefficient doubles, and the coefficient on  $C_i\ pc^{US}\ D\ airport_i$  is negative and statistically significant. This suggests that the effect of the coltan shock is concentrated among sites which are

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<sup>64</sup>The price of gold is stable between 1999 and 2000. The result is identical when I include the gold interaction, which is to be expected since the price of gold is stable in 1999 and 2000.

in the proximity of an airport, and thus where coltan can be shipped to international markets.<sup>65</sup>

Fourth, spatial clustering of coltan endowments and spatially correlated errors could give rise to the Moulton problem, and thus to underestimate the relevant standard errors (Moulton, 1986). While I account for this by clustering the standard errors, Column (5) adds region *Territoire*\*year fixed effects. The results are unchanged when I include these controls.

Columns (6)-(9) include the year 1998 to allow additional robustness checks. Column (6) implements a falsification test by including the lead value of the main regressor, and the result is even stronger: the main coefficient rises to .20. Column (7) includes a lagged dependent variable and implements dynamic panel data GMM using Arellano-Bond, since estimating a fixed effects model with lagged dependent variable as a regressor would be biased. The results are identical to the results of the baseline specification. To account for pre-existing differential time trends, Column (8) includes coltan-specific linear trends as regressors. The results are even stronger. Column (9) presents the baseline specification with all robustness checks and the results are unchanged.

Turning to testable implication 3, an increase in the price of coltan should have a larger effect than an equivalent increase in the price of gold. The point estimates provide support for this testable implication 3 across columns. The gold price is negatively related to presence of a stationary bandit in gold mining sites. I then run a t-test that the coefficient on coltan is smaller or equal to the coefficient on gold in the baseline specification rejects the null hypothesis with a p-value of 0.03. Since the rise in the price of gold is prolonged, the null estimate on the gold interaction can capture differential effects of changes in the political environment. In order to show that the gold effect is not a product of selecting a time interval in the baseline specification which yields convenient results, Figures 7 and 8 present the estimated coefficient on gold for all combinations of start and end dates in the sample. In only less than 2% of regressions, the coefficient on gold is positive and statistically significant, consistent with testable implication 3.<sup>66</sup> In sum, the patterns of emergence of stationary bandits are consistent with the testable

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<sup>65</sup>A possible concern is the airports may be constructed at a low cost. The qualitative fieldwork suggests that mining areas were often located in remote forests controlled by numerous adverse armed groups. This made building new landing lanes very difficult in the short-run.

<sup>66</sup>Some coefficients are negative and statistically significant. The rise in the gold price, however, coincides with the rise in power of the Congolese army, which could act as a deterrent on stationary bandits in gold mining sites. When I control for gold time trends, the negative coefficients of gold are no longer significantly different from zero.

implications 1,2,3.<sup>67</sup>

## 7.2 Expropriation strategy: emergence of taxation contracts

Figure 9 shows the proportion of sites in which an armed actor collects regular taxes for all years, for sites endowed with coltan and sites not endowed with coltan, focusing on mining sites. While the proportion rises from .3 to .65 among coltan sites, it remains constant in sites not endowed with coltan. Again, the figure makes clear that the trends preceding the shock are identical in coltan sites and in sites not endowed with coltan, demonstrating that the differential increase in taxation is not picking up pre-existing differential time trends. Second, following the shock, taxation is persistent in coltan sites, before exhibiting patterns indistinguishable to the rates of taxation in sites not endowed with coltan. This is consistent with the presence of fixed costs to develop a taxation system (for instance, developing a relationship). Table 3 presents the econometric results and follows a structure identical to Table 2. The main coefficient is positive and significant: the demand shock for coltan led to the emergence of taxation in coltan sites.

Table 4 shows the results from a linear probability model with six different types of taxes as well as occurrence of pillages as dependent variables. Columns (1) through (7) use as dependent variables dummies indicating respectively the presence of the following types of expropriation: mineral output taxation, taxation of mining labor, poll taxes in the corresponding support village, taxes on food sales in the corresponding market of the support village, taxes on population transit in and out of the corresponding support village, taxes on daily activity of a mill in the corresponding support village, and pillaging in the corresponding support village. The coltan shock led to the emergence of mineral output taxation, mining labor taxation, and poll taxes, usually aimed to capture households' income.<sup>68</sup>

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<sup>67</sup>However, while the discrepancy in coefficients is consistent with the theoretical results, it alone is no evidence that the underlying mechanism the inability to tax gold output is the underlying mechanism leading to this result. This relationship would also be predicted on the basis of the lower real productivity of labor in gold. I re-scaled the estimated coefficients obtained from the baseline specification as derived in Appendix A, and reject the null at conventional levels of statistical significance.

<sup>68</sup>Pillages decrease, but the result is insignificant. This is not surprising. In the case of a single contender, the bandit may be tempted to decrease pillage. However, the presence of competing bandits generates ambiguous predictions on pillage. First, contestation decreases the effective time horizon, which potentially counteracts the main effect: while new stationary bandits may emerge and tax, weaker incumbent stationary bandits could be tempted to pillage before the entry of the new stationary bandit, in response to competition. Second, contenders sometimes use pillage to weaken the tax base of their opponent. Since the theoretical predictions are ambiguous, the main predictions do not focus on pillage.



### 7.3 Organized attacks

Figure 10 shows the the average number of attacks per site, for coltan sites as well as for sites not endowed with coltan. It also shows the average tax that armed groups obtain per kilogram of coltan output, as a proxy for the value of controlling a coltan site. While the average number of external attacks rises from .3 to 1.2 in coltan sites, they remain around .4 for sites not endowed with coltan. The output tax rate per kilogram rises in exactly the same proportion as the US price of coltan. Table 5 presents the econometric results. The main coefficient is statistically significant across columns, and is of the same magnitude as the coefficient for stationary bandits in Table 2.

While I do not observe conquest operations in mining sites, I observe it for their corresponding support village. Thus, I can map the average number of attempted conquests on support villages. The distance of the mine to the support village implies a smaller increase in the temptation to hold a monopoly of violence in the corresponding support village. The estimated coefficient, thus, will likely be an under-estimate of the effect in mining sites. Figure 11 plots the average territorial conquests attempted on the corresponding support villages, for support villages with coltan mining sites, and support villages with only sites that are not endowed with coltan. While the average number of conquest operations increases from .10 to .40 in support villages linked to a coltan site, it remains constant at .25 in support villages linked to no coltan site.

### 7.4 Spillovers effects on neighboring villages

In order to estimate spillovers, I first define the cluster within which I expect spillovers can be positive. Each support village is attached to multiple mining sites. The sites tend to be very remote, and the support village is in general the closest village to the sites. I focus on spillover effects of the sites on the corresponding support village.<sup>69</sup> Table 6 presents the results on the

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<sup>69</sup>The effect of the coltan shock on coltan sites may spillover on the corresponding support village for various reasons. First, there can be direct economic and institutional spillovers stemming from changes in the profitability output at the mine. For instance, if populations working in the site live and consume in the support village, the profitability of holding the monopoly of violence in the support village will increase whenever the value of output at the site increases. In addition, if stationary bandits derive disutility from settling at the site, a rise in the profitability of holding a monopoly of violence at the site may induce stationary bandits to settle at the support village. Second, there can be economic and institutional spillovers stemming from strategic interactions between potential stationary bandits at the support village and the site, who take into account the direct spillovers on each other and adjust their decision whether to settle in response to each others' strategy. For instance, the decision of whether to settle in a support village by one armed actor and the decision of whether to settle in a mining site by another may be complements if there are positive migration effects, or if they benefit from sharing fixed costs of investments in state capacity. They may be substitutes if settling in the proximity of each other

linear probability model for village level outcomes used to estimate spillovers on the corresponding support village of the mining sites. The main regressor,  $C_i p_{c,t}^{US}$ , is computed coding as 1 a support village of at least one coltan mining site, and interacting this dummy with the logarithm of the US price of coltan. The columns use as outcome variables the following dummies: whether a stationary bandit is settled at the support village; whether an armed actor regularly collects poll taxes at the support village; whether armed men organized external attacks on the support village; whether armed men organized external attacks on the support village which were specifically aimed at attempting conquest and obtaining the support village monopoly of violence; whether armed actors organized external attacks on the support village which were specifically aimed at pillaging (acquiring resources quickly and violently); whether a stationary bandit settled in the support village in a given year increased his stock of guns, usually AK47. Standard errors are clustered at the level of the support village\*year. The table shows that there are positive spillovers arising from the mining sites on the corresponding support village. An increase in the price of coltan leads to the emergence of stationary bandits in corresponding support villages, the emergence of poll taxes, the presence of external attacks, the presence of conquest operations, as well as the accumulation of guns by stationary bandits.

## 7.5 Persistence of stationary bandits' fiscal capacity

Historical accounts of the formation of European states suggest that rulers created state capacity, and in particular fiscal capacity, as a result of a temporary need for public revenue to finance wars, and that fiscal capacity persisted in the aftermath of the wars (Besley and Persson, 2008, Salanie, 2011, Tilly, 1990). Using the fact that the coltan shock was temporary, I can estimate the persistence of stationary bandits' fiscal capacity.

Figures 6 and 9 plot stationary bandits and taxation in coltan and other sites between 1995 and 2012. Stationary bandits and taxation emerged in response to the coltan demand shock and persisted for various years despite the return of coltan prices to levels preceding the coltan shock. Table 7 presents the analysis of persistence of stationary bandits in a regression framework.<sup>70</sup>

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also decreases their costs of attacking each other. I ignore the distinction between direct spillovers and indirect spillovers stemming from the strategic response by stationary bandits in support villages, and instead estimate the total spillovers using a reduced form approach. Acemoglu, Garcia-Jimeno, and Robinson (2014) find evidence for strategic complementarities in state capacity investments across villages.

<sup>70</sup>The analysis of persistence of taxation is even stronger, and unreported here but available upon request.

Table 7 shows the estimates from a linear probability model regressing the presence of a stationary bandit on the lagged values of the main regressor,  $C_i p_{c,t}^{US}$ . Columns (1)-(4) replicate the baseline specification, but include the lags. The coefficient on the first lag of  $C_i p_{c,t}^{US}$  suggests that the coltan demand shock led to the emergence of stationary bandits which persisted for two years after the shock, despite the sudden and permanent reversal of coltan demand in 2001. However, the results in Columns (1)-(4) may not be due to persistence (defined as autocorrelation in the dependent variable), 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 due to the potential biases that arise in the presence of lagged dependent with fixed effects. 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 strongly persistent. Column (6) adds the second lag of stationary bandit and the results are unchanged. A remaining alternative explanation, however, is that stationary bandits persisted despite the sudden decrease in global prices, simply because the local price remained high in the years following the coltan demand shock, which allowed them to continue generate revenues from taxation. Anecdotal evidence, survey data on expectations, and Figure 2 suggest that local coltan traders continued to demand coltan after the sudden price decrease of the start of 2001, because they expected that the world price of coltan would rise again. To rule out that continued local demand for coltan is accounting for the persistence of stationary bandits, Column (7) includes the average price of coltan paid by traders at the site level, collected in the survey.<sup>71</sup> 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  $C_i p_{c,t}^{US}$  in order to circumvent endogenous location of stationary bandits. The results are unchanged, and

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<sup>71</sup>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.

the estimated impact of lagged stationary bandit on stationary bandit is close to 1.

Overall, the empirical findings presented in this section suggest that stationary bandits emerge endogenously where potential tax revenues rise as a result of shifts in global demand, and persist in the aftermath, consistent with the presence of a fixed cost of developing fiscal capacity (Besley and Persson, 2009, Tilly, 1990).

## 7.6 Trajectories of state formation

The previous sections have shown that the returns to taxation, where output is easy to tax, make stationary bandits, taxation, and protection more likely. These are likely to persist beyond the shock. However marginally unprofitable a rise in the price of gold is for outside stationary bandits, it is nevertheless possible for existing stationary bandits to choose other governing strategies to capture the rise in the value of the economic transactions they struggle to tax — to invest in fiscal capacity. I next examine how the type of fiscal administration that stationary bandits create responds to the returns to capture the flow of economic transactions in gold areas. To do so, I focus on the support village for two reasons. First, the governance data was collected only in support villages. Second, since gold output is unobservable but most other economic transactions are, armed groups are more likely to create an administration to capture other economic transactions at the village.

Table 8 reports the results of a linear probability model where I regress governance outcomes on mineral endowment, interacted with the relevant mineral price. Since the gold shock and coltan shocks occur in different periods, I include armed group fixed effects for the groups governing the village, to examine changes in governance strategies by stationed groups instead of capturing compositional effects that may coincide with the timing of the price shocks — a selection bias arising from sorting.

Column (1) uses a dummy indicating the presence of a poll tax as dependent variable. The coltan and gold price shocks have similar effects on the probability that a poll tax is observed in the village, and their magnitudes are statistically indistinguishable, yet the coefficient on the gold shock is only marginally significant. Similarly for columns (2) and (3), which focus on taxes at the agricultural market used by the village and on taxes on the village mill. Columns (4)-(6) report the key governance direct administration outcomes. Column (4) shows that groups are more likely to create a tax administration in response to an increase in the price of gold —

this effect is absent, in fact reversed, in support villages for coltan sites, suggesting groups focus their efforts at the production site instead. Column (5) shows that the price shock increases the probability that a stationary bandit rules the village completely, and subverts the rule of traditional chiefs — as opposed to sharing or delegating powers to the Chief. This effect is absent in coltan support villages. Column (6) shows that the gold price shock leads groups to invest more in the creation of justice administration and enforce disputes themselves, instead of letting traditional Chiefs doing so — this effect is absent, in fact reversed in coltan support villages. While column (7) suggests that the coltan and gold shocks have no discernible effect on the households' perceptions that the security provision is effective, column (8) indicates that the gold shock is more likely to reduce support for the group — an effect absent for the gold shock. This pattern of results suggests that in response to the increase in the value of potential tax revenues, armed groups who nevertheless create a monopoly of violence in gold support villages — despite the increase in potential tax revenues being lower than in response to the increase in the price of coltan — are more likely to create a heavy extractive administration to capture such increase, leading to increased discontent among the population. The strategies used by stationary bandits to capture such increase in value in gold village do not seem to hinge on attempts at legitimation, despite efforts to administer justice, as evidenced by the absence of an effect on perceived security effectiveness and the increased discontent among the population.

## 8 Discussion

In this section, I discuss quality of the data using external sources, and the impact and relevance of stationary bandits.

### 8.1 Measurement error

First, the data on stationary bandits benchmark very well with well-known historical junctures, which provides support to the quality of the data. Figure 3 plotted the survey-based measures of armed groups' occupation of villages in the sample on years. Stationary bandits emerge in 1996, as expected, coinciding with the AFDL rebellion. Stationary bandits re-emerge at the time of the RCD rebellion and Mayi-Mayi resurgence in 1998. They progressively disappear in 2003/2004,

coinciding with the last years of the Second Congo War, when the RCD was known to gradually disengage, and the partial re-integration of Mayi-Mayi factions into the Congolese Army. Second, the data on attacks also fit the known historical evidence on major episodes of the Congo Wars. Figure 14 plots the survey-based measures of armed groups' attacks on villages in the sample on years. The recorded attacks map precisely to the known phases of the war: the spike in 1996 by the AFDL corresponds to the well known timing of the AFDL combats in 1996. The resurgence in attacks between 1998 and 2003 corresponds to the RCD rebellion and its resistance by the Mayi-Mayi.<sup>72</sup> Furthermore, the data captures the well-documented drastic rise in attacks by the FDLR in 2009, 2010, 2011, in response to the Kimia II operation led by the Congolese Army.<sup>73</sup> Also, attacks recorded by the survey also capture the contemporaneous rise of the Raia Mutombokis since 2011. Third, local prices benchmark the world prices. Figure 2 shows that the survey-based recall prices closely track the international world price. The pattern of local prices further captures the well-known fact that local traders expected the price to rise back to its peak, once the world price fell.<sup>74</sup> Overall, the data on prices, armed groups, and attacks match the historical evidence.

The data could nevertheless contain systematic under-reporting bias. To provide confidence against the threat of under-reporting, I assigned violent events geo-coded by an external dataset (ACLED) to circles around the surveyed villages. The ACLED dataset contains 3,500 violence events since 1997, coded by perpetrator and type of event. Unlike the data collected in this study, the ACLED data is based on news reports. I compare this data to my source that contains the number of attacks on villages.<sup>75</sup> Figure 15 shows that the ACLED dataset systematically reports less violence around the selected villages than the current survey. The gap between ACLED and the survey is especially strong during the Second Congo War and in particular during the coltan shock. While it is possible that this difference between the survey and the ACLED data is due to the unobserved possibility that villagers over-report violent events in the survey, under-reporting due to memory loss and fear of retaliation is more likely given the nature of the data and the fact that the ACLED data appears to miss the pattern of events that characterize the Second Congo War, while the present data does not. The patterns thus suggest that the survey improves upon the ACLED dataset for the locations for which I have data. I then correlate the data to

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<sup>72</sup>There is also a sharp spike exactly in 2004, corresponding to the well documented timing of the CNDP rebellion. I do not report it for clarity of the Figure.

<sup>73</sup>See Sanchez de la Sierra (2014) for additional sources documented this rise in attacks.

<sup>74</sup>See online appendix F and United Nations Security Council (2002)

<sup>75</sup>When an event falls in circles of more than one village, I allocate the event to all corresponding villages.

ACLED's data in an OLS framework. Regression estimates for the variable conquest attacks in the neighborhood of the village are positive and significant (Table 9). In addition, attacks reported by my survey are less likely to be reported in ACLED when the villages were under RCD occupation (suggesting that the source of under-reporting in ACLED could be obstruction of information), which is especially plausible for attacks that are smaller in scale (pillages).<sup>76</sup>

## 8.2 Are stationary bandits good?

I can use my data to examine whether these stationary bandits have positive welfare effects by estimating production and growth differentials between stationary bandits' mining sites and mining sites in which a stationary bandit is absent. If stationary bandits' protection allows to increase production, production should increase *more* in mining sites in which there is a stationary bandit. Figure 16 shows the median volume produced by the average miner in coltan sites over the years, for sites in which a stationary bandit is present in 2000 and sites in which there is not.<sup>77</sup> In response to the coltan shock, most production increases in coltan mining sites occurs where a stationary bandit is present. However, this relationship may be the result that stationary bandits self-selected into the most profitable coltan mining sites. Since the distance to a local airport proxies for trade costs and thus inversely relates to the value of holding a monopoly of violence, I regress production on year effects and control for year effects interacted with distance to the closest airport. Figure 18 plots the residuals, and shows that the results remain unaffected. Coltan sites in which a stationary bandit was present, even after controlling on observable characteristics correlated with the profitability of controlling the mining site, benefit most from the coltan shock. Obviously, this result relies on the assumption that stationary bandits select coltan sites only on the basis of observable distance to the closest airport. Nevertheless, it is consistent with the interpretation that the welfare gains from the protection provided by stationary bandits dominate the welfare losses from the distortions their taxation generates on effort and investment. It is also consistent with Sanchez de la Sierra (2014), where the sharp departure of stationary bandits from targeted villages as a result of a high level peace agreement led output to decrease.

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<sup>76</sup>This result applies even stronger with RCD perpetrated violent events, consistent with reporting bias.

<sup>77</sup>Figure 17 shows the results with mean production instead.

### 8.3 Where do we go from here: bandits or states?

A limitation of the current study is its focus on simple forms of territorial control. Indeed this study focuses on rulers whose technology of violence allows them to own the monopoly of violence in a small territory, a village or a site, and thus need little administrative capacity, similar to early “inchoate” states (Claessen and Skalnik, 1978). The attempts of rulers to govern larger territorial units creates deeper agency problems inside their organization, and administration, and mutual dependencies between rulers and individuals who are able to produce violence and implement policy choices, the administrators. In the process of transformation of the early state into modern states, the creation of a professional bureaucracy is indeed crucial (Claessen and Van de Velde, 1991). The historically anomalous attributes of today’s modern states, such as professionalized bureaucracies and legitimacy have shaped the study of state origins. However, such attributes took centuries to emerge from more primitive forms of states, some of which never succeeded, while others evolved. Rather than postulating teleological accounts of the formation of current states on the basis of today’s states, the view of states as stationary bandits provides behavioral predictions that match the first stages of the historical state formation process and that can be falsified. Future research should examine the conditions under which local monopolies of violence are able to coordinate into larger units, develop an administrative apparatus, and how the administration plays a fundamental role at shaping the decisions of rulers (Greif, 2008). The study of later stages of state formation is beyond the scope of this paper.

Overall, this paper has underlined that pessimistic views on what stationary bandits actually do, as well as idealized conceptualizations of the state likely influenced by the recent anomaly of the welfare state, underpin the failure to recognize the relevance of stationary bandits and armed groups for the process of state origins and the study of state behavior. They ignore the coercive nature of the state its purely extractive origins among pristine states, which aimed at extracting economic surplus for a small armed elite. The stationary bandits I observe are solving exactly such problem, which includes complex issues of governance such as legitimation and administration.<sup>78</sup>

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<sup>78</sup>Economists also recognized the criminal origins of states and the relevance of economics of crime: “The study of 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.” (Baumol, 1995).



## 9 Conclusion

This paper provides an empirical basis to study the first stages of state formation in economics, but also contributes conceptually to unresolved debates about the nature and origins of the state in other disciplines. The findings mostly provide support for conflict theories of state formation, where state structures emerge through coercion in order to increase expropriation, although they do not discredit a contractarian view of the origins of the state as a possibility. They suggest that economic analysis can go a long way to explain empirical patterns of state formation.

The results have implications for policy. Armed groups are a topic of growing interest among governments. This study provides econometric evidence of the relationship between violence and mineral endowments in the DRC. I find that mineral price shocks lead to violence between armed groups in order to acquire the territory that is mineral rich. I also demonstrate that fluctuations in global demand for electronic products can have profound long-lasting consequences for violence and institutions in villages supplying required minerals. Stationary bandits emerge in sites endowed with that mineral, design taxation plans, and remain in the aftermath of the shock.

My findings suggest a similarity between violent organizations and states. Like states, actors who can organize violence can exert coercion in order to expropriate, but also to maintain a monopoly of violence, tax, and provide protection. Their strategies might turn in favor of the population when the population can be a profitable tax base, leading potentially to the first stages of state-like structures. Future research in the political economy of state formation should examine the conditions under which rulers successfully coordinate their administrators in order to maintain and expand the monopoly of violence (Greif, 2008).

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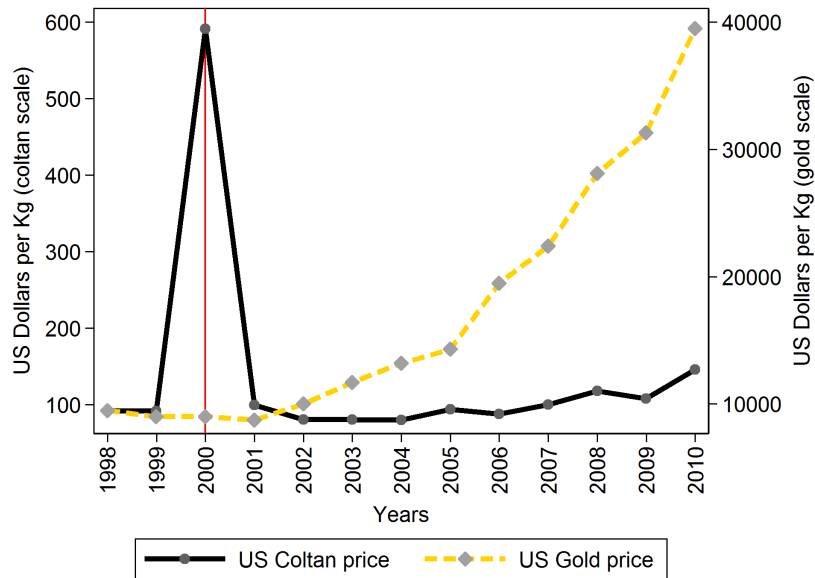
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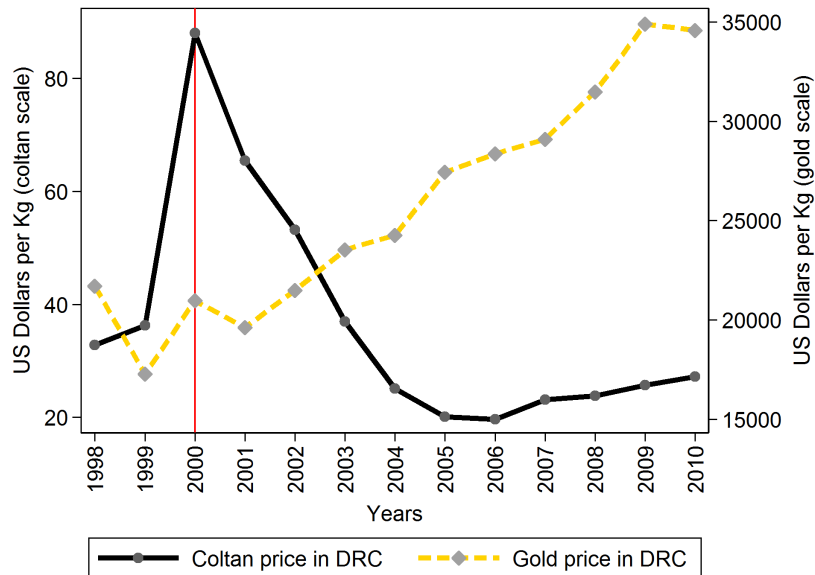
# Figures and Tables

Figure 1: World prices of coltan and gold



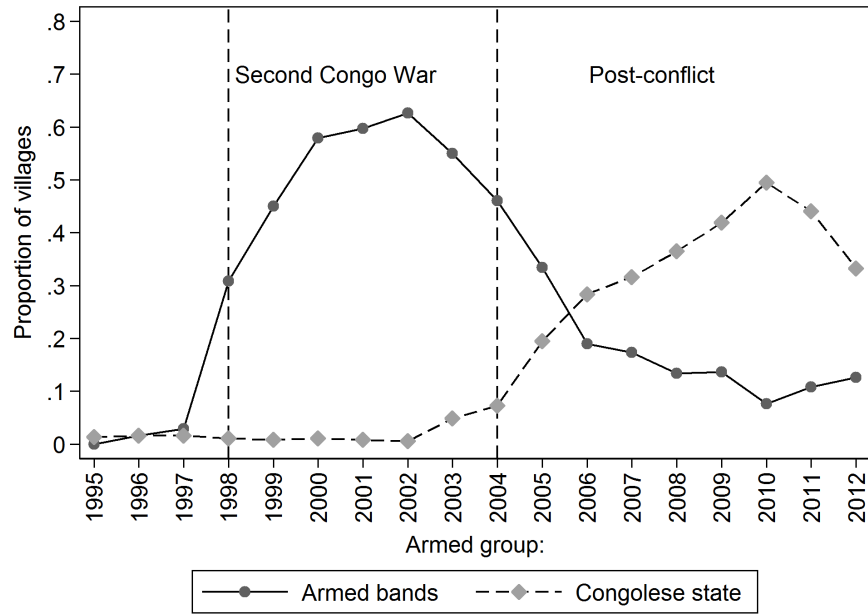
*Notes:* This figure plots the yearly average price of gold and coltan in the US market, in USD per kilogram. The price of coltan is scaled on the left vertical axis and the price of gold in the right axis. Source: United States Geological Survey (2010).

Figure 2: Local prices of coltan and gold



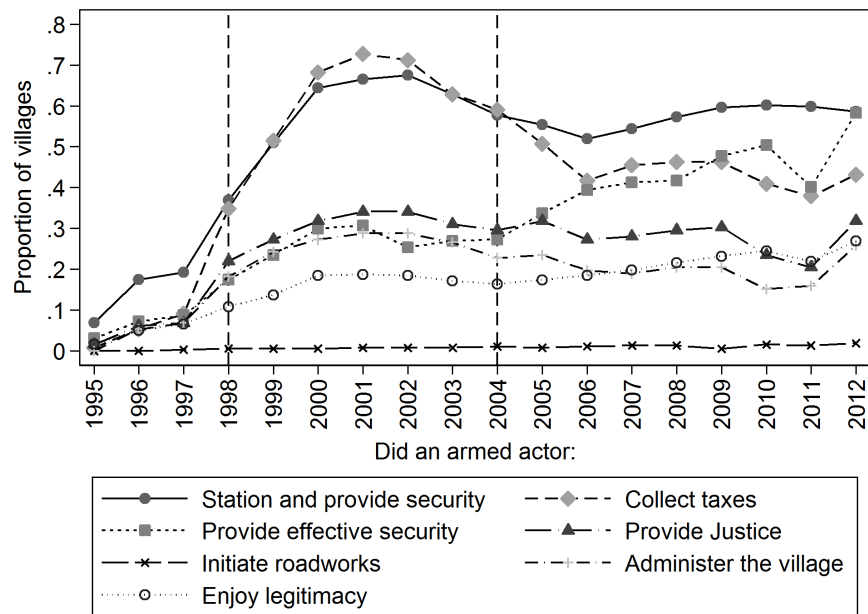
*Notes:* This figure plots the yearly average price of gold and coltan in Sud Kivu, in USD per kilogram, as measured in the survey. The price of coltan is scaled on the left vertical axis and the price of gold in the right axis. Source: United States Geological Survey (2010).

Figure 3: Stationary bandit's organizations



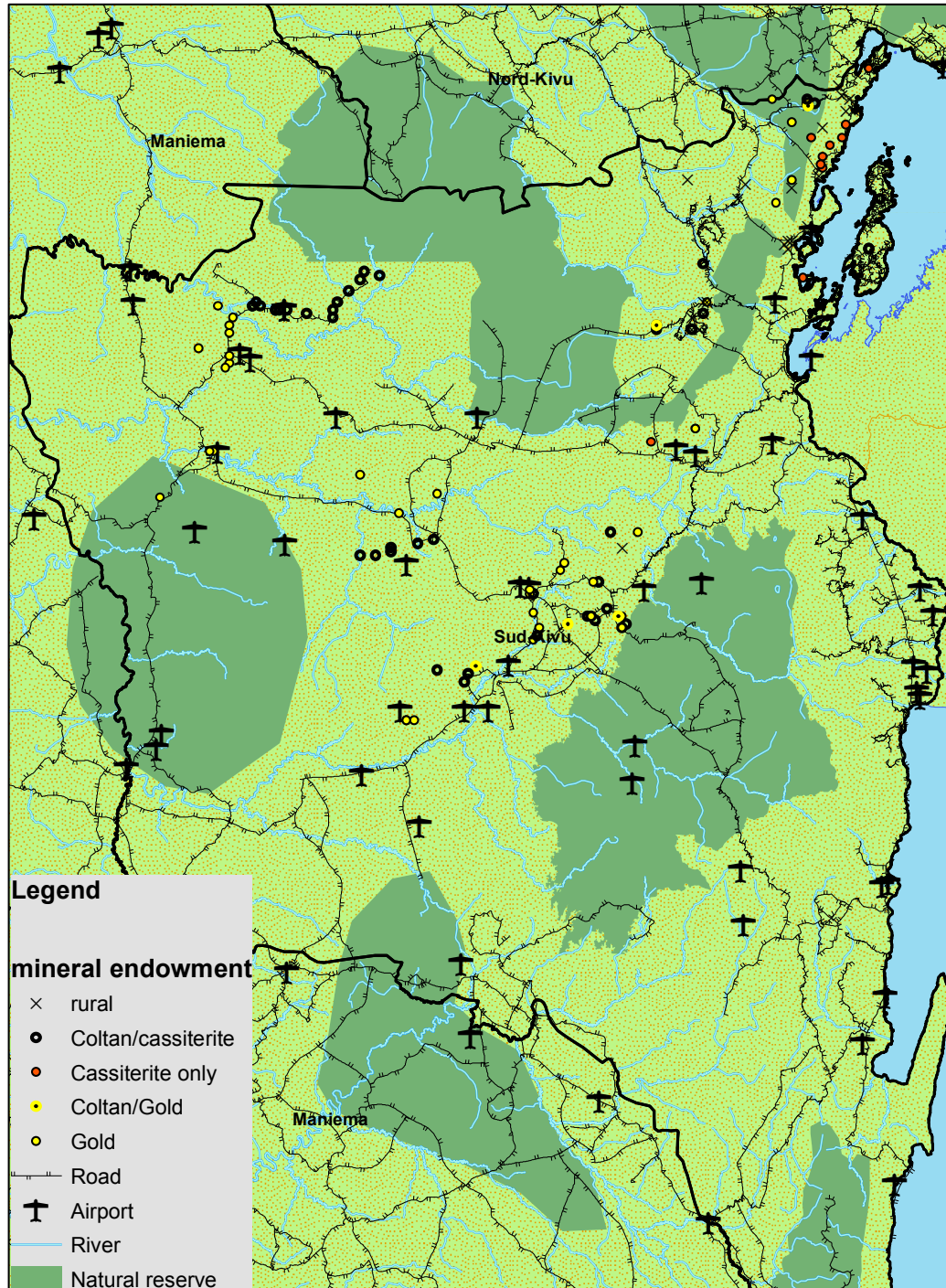
*Notes:* This figure graphs the proportion of sites in the sample under the control of armed actors on year. The solid line indicates the proportion of sites which are controlled by armed bands who are not the Congolese Army. The dashed line indicates the proportion of which are controlled by the Congolese Army. The data fits the historical phases of the conflict and post-conflict periods. The dashed vertical lines indicate the start and end of the Second Congo War. The Congolese Army progressively replaces irregular armed groups after 2004, the end of the second Congo War. However, the state integrated local armed groups into the national army after 2003, only partially changing their structures of command or autonomy. The distinction between the Congolese Army and irregular armed groups is thus often blurred.

Figure 4: Stationary bandits' activities



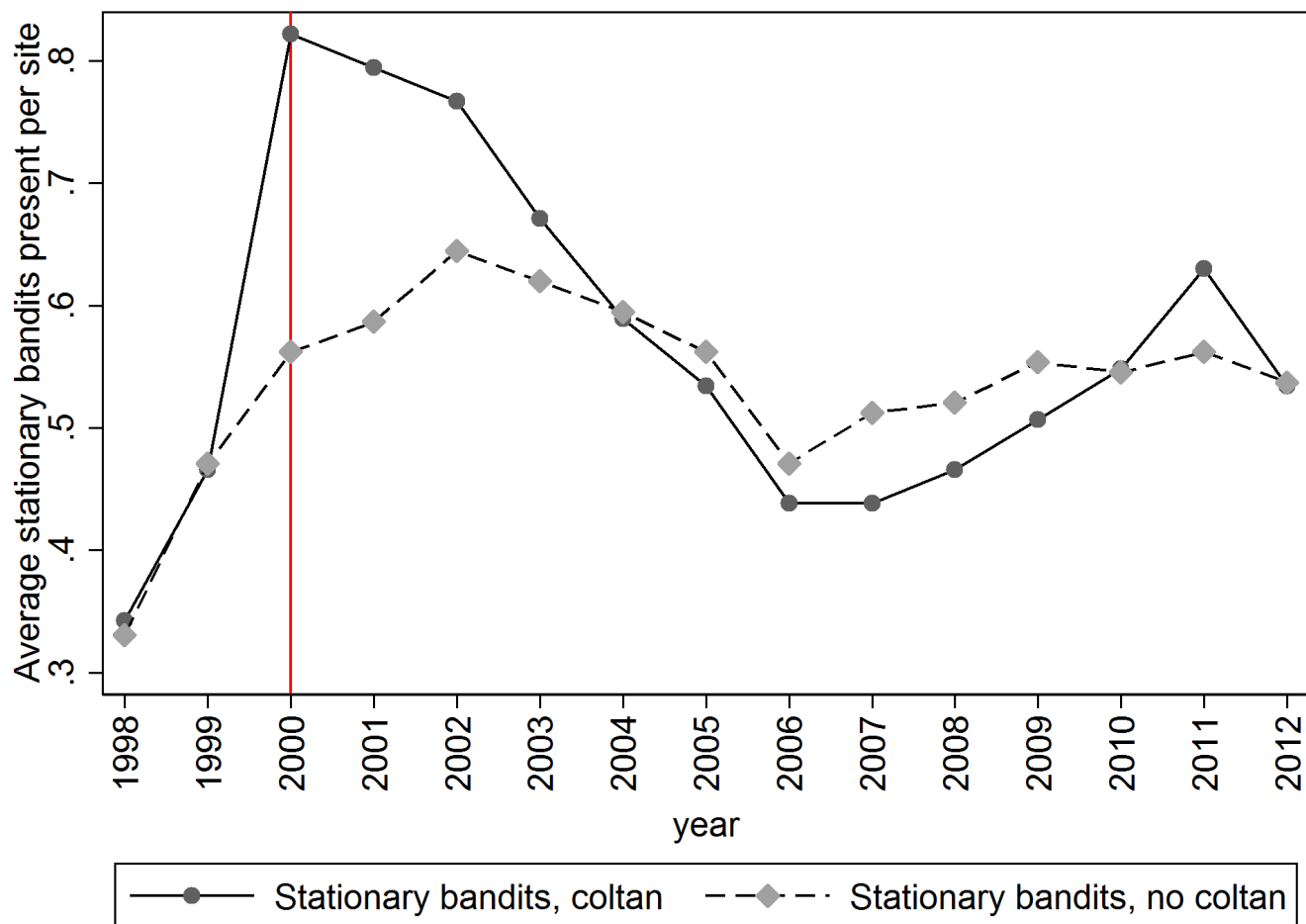
*Notes:* This figure graphs the proportion of villages in the sample where armed actors implement one of the following activities, on year: station and provide security, collect taxes, provide effective security as reported by villagers, provide justice, initiate roadworks, administer the village, developed legitimacy (measured by self-reported popular support by villagers).

Figure 5: Support villages included in the sample



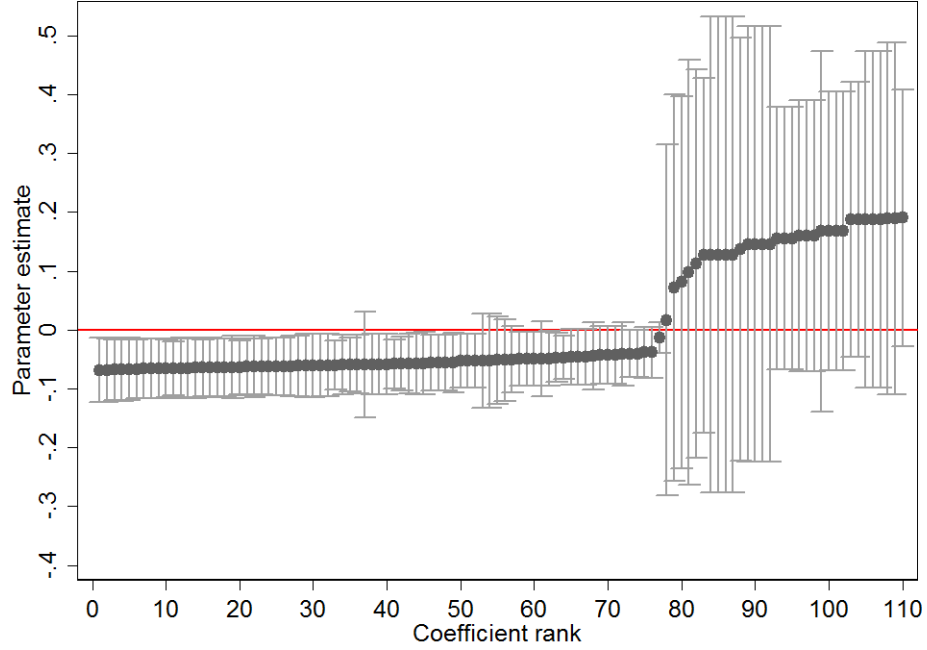
*Notes:* This map presents the location of the support villages in which the survey took place in Sud Kivu. The villages endowed with coltan only are indicated in black circles. The villages endowed with coltan and gold are indicated as black dots in golden circles. Villages endowed with cassiterite only are indicated in orange. Purely agricultural villages are indicated as crosses. In each Territoire (Shabunda, Mwenga, Walungu, Kabare, Kalehe) the data collection team assembled the data in all coltan villages that were accessible to the survey teams. In addition, it also collected data in a sample of gold villages randomly selected within each administrative division (Territoire). In the Territoire of Kalehe, I also collected data in agricultural villages, which I sampled by matching to the mining support villages in Kalehe prior to the survey using pre-survey geographic characteristics.

Figure 6: Demand shock for coltan and presence of stationary bandits



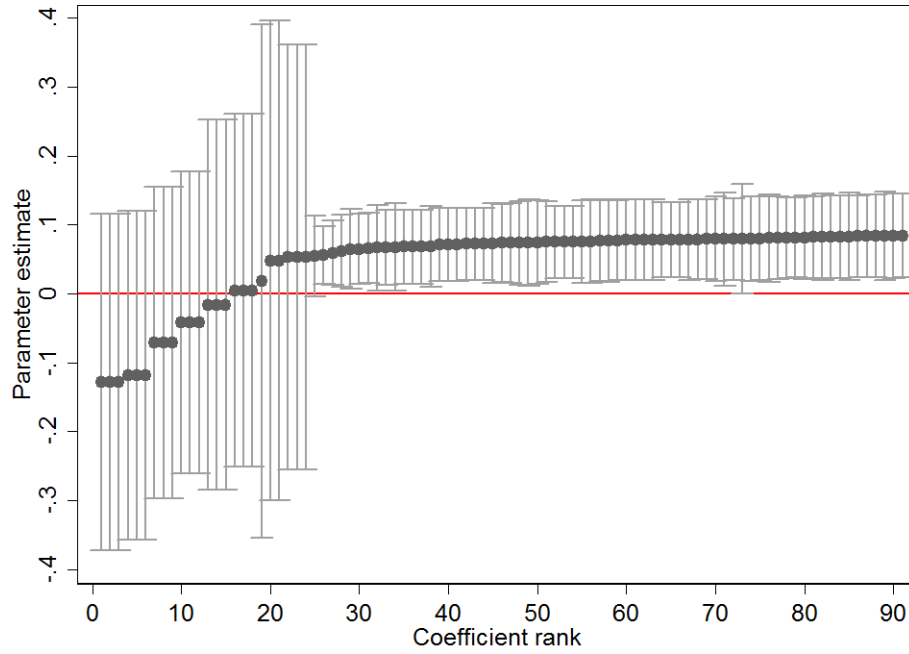
*Notes:* This figure plots the proportion of villages in which a stationary bandit is present on years. I take the variable stationary bandit from the site survey, in which the specialists are asked to list past “organizations of security” in the site. A stationary bandit (“organization of security” in the survey) is defined as an armed actor who holds the monopoly of violence in a given site for at least 6 months (approximately). The solid line graphs the average number of stationary bandits per year for mining sites that are endowed with coltan deposits, and the dashed line reports the same quantity for mining sites not endowed with coltan deposits.

Figure 7: Effect of the price of gold on stationary bandits at gold sites, all time intervals



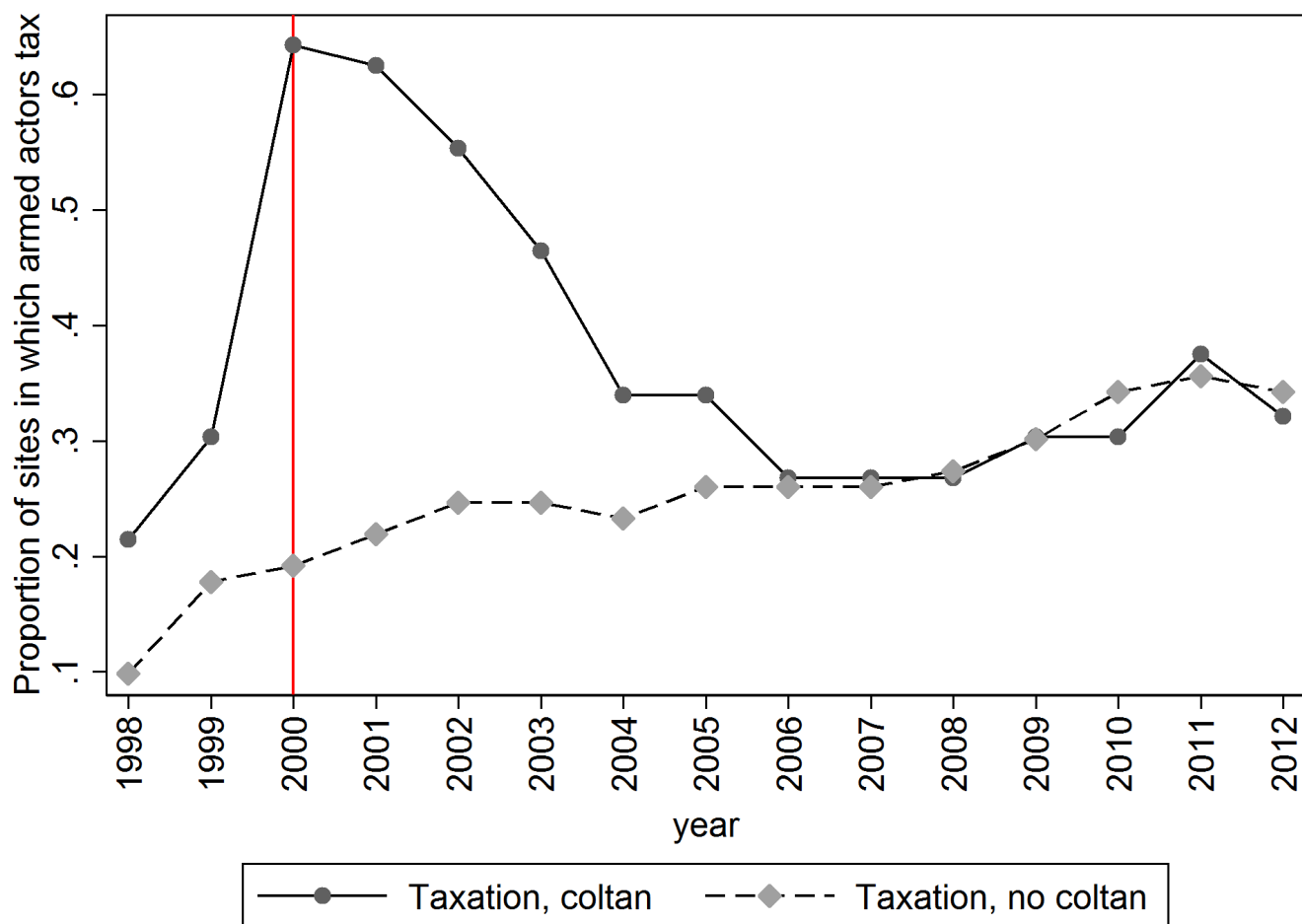
*Notes:* This figure plots the estimated coefficients on gold endowment, interacted with the world price of gold, from the baseline specification using all possible time intervals. Intervals indicate 95% confidence intervals.

Figure 8: Effect of the price of coltan on stationary bandits at coltan sites, all time intervals



*Notes:* This figure plots the estimated coefficients on coltan endowment, interacted with the world price of coltan, from the baseline specification using all possible time intervals. Intervals indicate 95% confidence intervals.

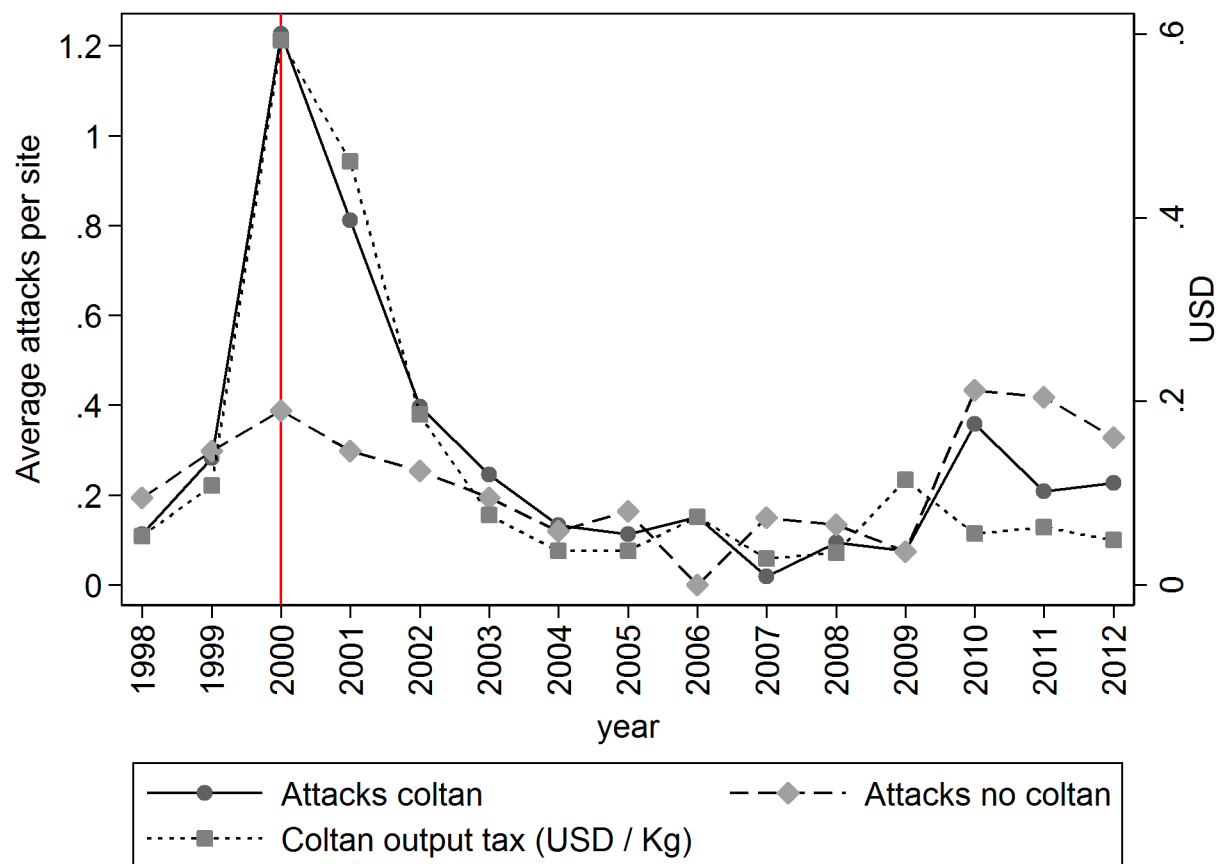
Figure 9: Demand shock for coltan and presence of taxation



*Notes:* This figure plots the average number of sites where an armed actor collects taxes regularly on years. I take this variable from the site survey, in which the specialists are asked to list past taxes in the site. Taxes by an armed actor are defined in the survey as a mandatory payment on mining activity which is regular (sporadic expropriation is excluded), stable (rates of expropriation are stable) and anticipated (villagers make investment decisions with knowledge of these expropriation rates and that these will be respected). The solid line graphs the average number of mining sites where an armed actor collects regular taxes for mining sites that are endowed with available coltan deposits, and the dashed line reports the same quantity for mining sites that are not endowed with coltan deposits.

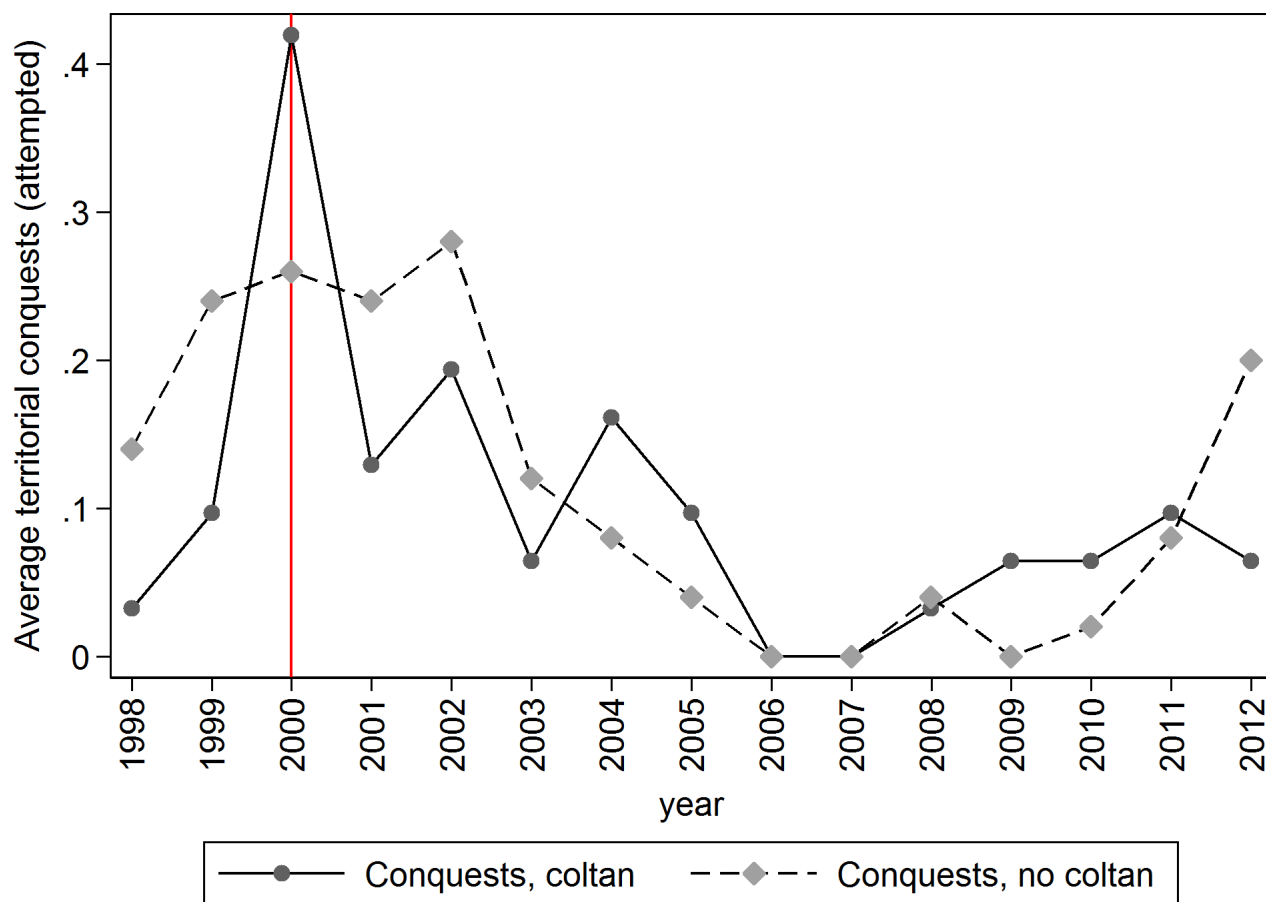


Figure 10: Demand shock for coltan, output tax, and external attacks on site



*Notes:* This figure plots the average number of mining sites with an external attack, as well as the value of taxes to be paid per kilogram of coltan produced. An external attack is defined as a violent operation in which an armed band from outside the site travels to the site and uses explicit violence - whatever its purpose. Most external attacks are conquest attempts, whereby armed bands attempt to overthrow the existing stationary bandit in order to hold the monopoly of violence at the mining site. The solid line graphs the average number of mining sites where armed actors who are not the stationary bandit implement an external attack for mining sites that are endowed with available coltan deposits, the dotted line reports the same quantity for mining sites that are not endowed with coltan deposits. The dashed line reports the average tax to pay for the armed actor holding the monopoly of violence per kilogram produced.

Figure 11: Coltan demand shock and conquest attacks on the corresponding support village



*Notes:* This figure plots the average number of conquest attempts on the corresponding support villages, attached to mining sites. A conquest attempt is defined as an operation in which armed bands attempt to overthrow the existing stationary bandit in order to hold the monopoly of violence at the site, by fighting. The solid line graphs the average number of conquest attempts for support villages with at least one site that is endowed with coltan deposits, the dotted line reports the same quantity for support villages for which no mining site has coltan.

Table 1: Summary statistics, year 1999

Mining sites						
Stationary bandit	128	0.58	0.46	0.12	0.19	Survey
Mining labor tax by armed actors	126	0.15	0.11	0.04	0.50	Survey
Mining ouptut tax by armed actors	125	0.00	0.24	-0.24	0.00 ***	Survey
External attacks	117	0.30	0.20	0.11	0.48	Survey
Support villages attached to mining sites						
Stationary bandit	112	0.68	0.55	0.13	0.18	Survey
Poll tax by armed actors	111	0.55	0.56	-0.01	0.92	Survey
Cassava sales tax by armed actors	113	0.18	0.11	0.07	0.30	Survey
Transit tax by armed actors	113	0.19	0.16	0.03	0.66	Survey
Mill tax by armed actors	113	0.09	0.11	-0.02	0.73	Survey
Effective security provision	112	0.25	0.21	0.04	0.53	Survey
Justice provision	112	0.36	0.18	0.18	0.04**	Survey
Administration provision	112	0.30	0.18	0.13	0.12	Survey
Rely on chief for household taxation (Indirect rule)	112	0.45	0.32	0.13	0.18	Survey
External attacks	112	0.34	0.16	0.18	0.03**	Survey
Conquest attacks	113	0.19	0.11	0.09	0.37	Survey
Assets' expropriation attacks (pillages)	113	0.11	0.09	0.02	0.78	Survey
Distance to the closest natural reserve	102	15.46	14.97	0.49	0.83	Survey and RGC
Distance to the closest lake	102	80.97	92.60	-11.64	0.30	Survey and RGC
Distance to Bukavu	102	93.97	96.03	-2.07	0.81	Survey and RGC
Distance to Rwanda	102	86.72	93.82	-7.10	0.49	Survey and RGC
Distance to the closest river	102	5.07	5.39	-0.32	0.76	Survey and RGC
Distance to the closest bridge	102	6.35	13.42	-7.07	0.00***	Survey and RGC
Distance to the closest airport	102	14.39	16.29	-1.90	0.34	Survey and RGC
Accessible by car	92	0.21	0.16	0.05	0.51	Survey
Accessible by motorbike	92	0.33	0.34	-0.01	0.95	Survey
Phone network	92	0.05	0.06	-0.01	0.80	Survey
	Sample size	Gold	Coltan	Difference	p-value	Source

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. This table presents the summary statistics of the main variables in the year 1999, by type of mineral endowment at the site. Every mining site is attached to only one support village, which is in general the closest village and may have multiple mines attached to it. I collected most of the data organizing a data collection project with 10 surveyors, but I use the support village GPS location I collected and data from Référentiel Géographique Commun (2010) in order to compute Euclidean distances between the support village and the closest geographic feature of interest.

Table 2: Effects of price shocks, presence of stationary bandit

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Coltan(i) X pc(t)	0.07** (0.03)	0.10*** (0.03)	0.17*** (0.04)	0.21*** (0.05)	0.11*** (0.03)	0.20*** (0.03)	0.12*** (0.02)	0.13** (0.05)	0.28*** (0.08)
Coltan(i) X pc(t) X D road(i)			-0.08 (0.07)						-0.07 (0.07)
pc(t) X D road(i)			0.03 (0.03)						0.03 (0.04)
Gold(i) X pg(t)	-0.03 (0.03)								
Coltan(i) X pc(t) X D airport(i)				-0.13** (0.06)					-0.10 (0.06)
pc(t) X D airport(i)				0.01 (0.02)					0.00 (0.04)
Coltan(i) X pc(t+1)						0.06** (0.03)			
Constant	0.27** (0.11)	0.29*** (0.06)	0.17* (0.09)	0.20*** (0.07)	0.27*** (0.06)	-0.03 (0.10)	0.00 (0.00)	41.97 (46.28)	91.16* (49.25)
Observations	2,134	388	360	360	388	582	388	582	540
R-squared	0.68	0.87	0.87	0.88	0.88	0.76		0.79	0.82
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Region*Year FE	NO	NO	NO	NO	YES	YES	NO	NO	YES
Arellano-Bond	NO	NO	NO	NO	NO	NO	YES	NO	NO
Coltan time trends	NO	NO	NO	NO	NO	NO	NO	YES	YES
Sample	98-08	99-00	99-00	99-00	99-00	98-00	98-00	98-00	98-00

*Notes:* \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. This table presents the results on the linear probability model for the dependent variable *stationary bandits*. A stationary bandit is defined as an armed actor who holds the monopoly of violence in a given site for at least 6 months. The baseline specification is  $Y_{it} = \beta_t + \alpha_i + \gamma_c Coltan_i pc_t + \varepsilon_{it}$  where  $Coltan_i$  is a dummy indicating whether site  $i$  is endowed with available coltan, which is constant over time,  $pc_t$  is the logarithm of the US price of coltan, and  $\beta_t$  and  $\alpha_i$  are year and site fixed effects. Column (1) presents the results for the whole period, 1998-2008 and includes a control for the US price of gold interacted with gold endowments at the site level. Column (2) replicates Column (1) using only 1999 and 2000 and excludes the gold interaction. Building upon column (2), column (3) adds a fully saturated model with interactions with  $D road_i$ , a dummy indicating whether the distance of the support village to its closest road is above the 50th percentile in the sample. Column (4) does the same with  $D airport_i$ , a dummy indicating whether the distance of the support village to its closest airport is above the 50th percentile in the sample. Column (5) adds region Territoire\*year fixed effects. Columns (6)-(9) include in addition the year 1998 to allow additional robustness checks. Column (6) implements a falsification test by including leads and lags of the main regressor. Column (7) includes a lagged dependent variable and implements Arellano-Bond. Column (8) includes coltan specific linear trends as a regressor. Column (9) replicates the baseline specification with all robustness checks. Standard errors are clustered at the support village level.

Table 3: Effects of price shocks, presence of taxation

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Coltan(i) X pc(t)	0.15*** (0.03)	0.17*** (0.04)	0.19*** (0.05)	0.29*** (0.06)	0.18*** (0.04)	0.23*** (0.03)	0.07*** (0.01)	0.16*** (0.06)	0.29*** (0.08)
Coltan(i) X pc(t) X D road(i)			-0.01 (0.08)						0.01 (0.07)
pc(t) X D road(i)			0.01 (0.02)						-0.02 (0.03)
Gold(i) X pg(t)	0.01 (0.03)								
Coltan(i) X pc(t) X D airport(i)				-0.17** (0.08)					-0.22*** (0.06)
pc(t) X D airport(i)				-0.00 (0.03)					0.07 (0.05)
Coltan(i) X pc(t+1)						0.05 (0.03)			
Constant	-0.16 (0.11)	-0.11 (0.09)	-0.17 (0.10)	-0.14 (0.09)	-0.13 (0.08)	-0.36*** (0.12)	0.00 (0.00)	-28.71 (54.65)	-11.57 (57.61)
Observations	1,417	258	240	240	258	385	256	385	358
R-squared	0.71	0.84	0.85	0.86	0.86	0.77		0.77	0.82
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Region*Year FE	NO	NO	NO	NO	YES	YES	NO	NO	YES
Arellano-Bond	NO	NO	NO	NO	NO	NO	YES	NO	NO
Coltan time trends	NO	NO	NO	NO	NO	NO	NO	YES	YES
Sample	98-08	99-00	99-00	99-00	99-00	98-00	98-00	98-00	98-00

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. This table presents the results on the linear probability model for the dependent variable *taxation* by armed actors. Regular taxes by an armed actor are defined as a mandatory payment on mining activity such that the payment is required on a regular basis, the rate is stable and can be anticipated by the population before they make investments and allocate labor. The baseline specification is  $Y_{it} = \beta_t + \alpha_i + \gamma_c Coltan_i pc_t + \varepsilon_{it}$  where  $Coltan_i$  is a dummy indicating whether site  $i$  is endowed with available coltan, which is constant over time,  $pc_t$  is the logarithm of the US price of coltan, and  $\beta_t$  and  $\alpha_i$  are year and site fixed effects. Column (1) presents the results for the whole period, 1998-2008 and includes a control for the US price of gold interacted with gold endowments at the site level. Column (2) replicates Column (1) using only 1999 and 2000 and excludes the gold interaction. Building upon column (2), column (3) adds a fully saturated model with interactions with  $D road_i$ , a dummy indicating whether the distance of the support village to its closest road is above the 50th percentile in the sample. Column (4) does the same with  $D airport_i$ , a dummy indicating whether the distance of the support village to its closest airport is above the 50th percentile in the sample. Column (5) adds region Territoire\*year fixed effects. Columns (6)-(9) include in addition the year 1998 to allow additional robustness checks. Column (6) implements a falsification test by including leads and lags of the main regressor. Column (7) includes a lagged dependent variable and implements Arellano-Bond. Column (8) includes coltan specific linear trends as a regressor. Column (9) replicates the baseline specification with all robustness checks. Standard errors are clustered at the support village level.

Table 4: Effects of price shocks by type of tax

VARIABLES	(1) Output Tax	(2) Labor Tax	(3) Poll Tax	(4) Food Tax	(5) Transit Tax	(6) Mill Tax	(7) Pillage
Coltan(i) X pc(t)	0.12*** (0.03)	0.07*** (0.02)	0.10*** (0.03)	-0.01 (0.02)	0.01 (0.03)	0.02 (0.02)	-0.04 (0.04)
Constant	-0.20*** (0.06)	-0.06 (0.06)	0.28*** (0.07)	0.11** (0.05)	0.13** (0.06)	0.01 (0.03)	0.24*** (0.09)
Observations	1,521	1,599	1,690	1,463	1,729	1,729	1,729
R-squared	0.60	0.72	0.56	0.61	0.59	0.72	0.12
Year FE	YES	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES	YES
Location	MINE	MINE	VILLAGE	MARKET	VILLAGE	VILLAGE	VILLAGE
Sample	99-00	99-00	99-00	99-00	99-00	99-00	99-00

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. This table presents the results on the baseline linear probability models for dependent variables dummies indicating whether a taxation instrument is used, as dependent variable. For village level taxes, the main regressor,  $Coltan_i X pc_t$  is computed coding as 1 all support villages where at least one site attached to it is endowed with coltan, and interacting this dummy with the logarithm of the US price of coltan. Standard errors are clustered at the level of the site\*year. All village level regressions, thus, also include the regressor computed using distance weights. Columns (1) and (2) show the results on dummies indicating mining taxes, respectively output tax (a tax in US dollars paid per kilogram produced, to be paid the mining site), and labor tax (a tax paid in US Dollars in order to get the right to work at the mine). Columns (3) to (6) examine taxes paid by the population of the support village attached to the mining site. Column (3) regresses a dummy indicating whether an armed actor collects poll taxes in the support village, Column (4) regresses a dummy indicating whether an armed actor collects taxes on the market used by the support village population (as indicator I use the tax per day to be paid by households selling cassava flour, a basic consumption good), Column (5) regresses a dummy indicating whether an armed actor collects taxes on population transit to enter and/or to exit the support village. Column (6) regresses a dummy indicating whether an armed actor taxes the mill of the support village. Column (7) regresses a dummy indicating whether the support village was pillaged as an additional form of expropriation. Standard errors are clustered at the level of the support village.

Table 5: Effects of price shocks, organized attacks

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Coltan(i) X pc(t)	0.12*** (0.04)	0.14*** (0.04)	0.13** (0.05)	0.15** (0.07)	0.13*** (0.05)	0.16*** (0.04)	0.05*** (0.01)	0.12 (0.08)	0.17 (0.11)
Coltan(i) X pc(t) X D road(i)			0.03 (0.09)						-0.03 (0.10)
pc(t) X D road(i)			-0.03 (0.03)						0.02 (0.06)
Gold(i) X pg(t)	0.03 (0.03)								
Coltan(i) X pc(t) X D airport(i)				-0.01 (0.09)					-0.06 (0.09)
pc(t) X D airport(i)				-0.02 (0.04)					0.05 (0.07)
Coltan(i) X pc(t+1)						0.02 (0.03)			
Constant	-0.19* (0.11)	-0.15 (0.10)	-0.11 (0.12)	-0.14 (0.11)	-0.15 (0.10)	-0.25* (0.14)	0.00 (0.00)	-34.28 (81.72)	-23.94 (91.29)
Observations	1,287	234	214	214	234	351	234	351	321
R-squared	0.24	0.71	0.69	0.69	0.71	0.42		0.42	0.46
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES	Y	YES	YES
Region*Year FE	NO	NO	NO	NO	YES	YES	NO	NO	YES
Arellano-Bond	NO	NO	NO	NO	NO	NO	YES	NO	NO
Coltan time trends	NO	NO	NO	NO	NO	NO	NO	YES	YES
Sample	98-08	99-00	99-00	99-00	99-00	98-00	98-00	98-00	98-00

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. This table presents the results on the linear probability model for dependent variable *external attack* by armed actors. An external attack is defined as a violent operation in which an armed band from outside the site travels to the site in order to produce violence. Most external attacks are conquest attempts, whereby armed bands attempt to overthrow the existing stationary bandit in order to hold the monopoly of violence at the site. The baseline specification is  $Y_{it} = \beta_t + \alpha_i + \gamma_c \text{Coltan}_i \text{pc}_t + \varepsilon_{it}$  where  $\text{Coltan}_i$  is a dummy indicating whether site  $i$  is endowed with available coltan, which is constant over time,  $\text{pc}_t$  is the logarithm of the US price of coltan, and  $\beta_t$  and  $\alpha_i$  are year and site fixed effects. Column (1) presents the results for the whole period, 1998-2008 and includes a control for the US price of gold interacted with gold endowments at the site level. Column (2) replicates Column (1) using only 1999 and 2000 and excludes the gold interaction. Building upon column (2), column (3) adds a fully saturated model with interactions with  $D \text{ road}_i$ , a dummy indicating whether the distance of the support village to its closest road is above the 50th percentile in the sample. Column (4) does the same with  $D \text{ airport}_i$ , a dummy indicating whether the distance of the support village to its closest airport is above the 50th percentile in the sample. Column (5) adds region Territoire\*year fixed effects. Columns (6)-(9) include in addition the year 1998 to allow additional robustness checks. Column (6) implements a falsification test by including leads and lags of the main regressor. Column (7) includes a lagged dependent variable and implements Arellano-Bond. Column (8) includes coltan specific linear trends as a regressor. Column (9) replicates the baseline specification with all robustness checks. Standard errors are clustered at the support village level.

Table 6: Effects of price shocks, spillovers on the corresponding support village

VARIABLES	(1) Stationary Bandit	(2) Village Poll Tax	(3) Attacks External	(4) Attacks Conquest	(5) Attacks Expropriation	(6) Guns Accumulation
Coltan(i) X pc(t)	0.07* (0.04)	0.07** (0.04)	0.09* (0.05)	0.09** (0.03)	-0.02 (0.05)	0.06** (0.03)
Constant	0.47*** (0.09)	0.39*** (0.07)	0.09 (0.10)	-0.06 (0.07)	0.15 (0.10)	-0.07 (0.05)
Observations	264	260	262	266	266	264
R-squared	0.83	0.86	0.70	0.72	0.59	0.63
Year FE	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES
Sample	99-00	99-00	99-00	99-00	99-00	99-00

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. This table presents the results on the linear probability models with village level outcomes as dependent variables in order to estimate spillovers on the corresponding support villages. The main regressor,  $Coltan_i X pc_t$  is computed coding as 1 all support villages where at least one site attached to it is endowed with coltan, and interacting this dummy with the logarithm of the US price of coltan. All columns include the baseline specification at the level of the support village, with support village and year fixed effects. Columns (1) to (6) respectively use as outcome variables the following dummies: whether a stationary bandit is settled at the support village; whether an armed actor regularly collects poll taxes at the support village; whether armed men organized external attacks on the support village; whether armed actors organized external attacks on the support village which were specifically aimed at attempting conquest and obtaining the monopoly of violence at the support village; whether armed actors organized external attacks on the support village which were specifically aimed at pillaging (acquiring resources quickly and violently); whether a stationary bandit settled in the support village in a given year increased his stock of firearms. Standard errors are clustered at the level of the support village\*year.



Table 7: Persistence of stationary bandits

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
stationary bandit(t-1)					0.74*** (0.03)	0.74*** (0.03)	0.74*** (0.03)	1.04*** (0.30)
stationary bandit(t-2)						-0.05** (0.02)	-0.05** (0.02)	
Coltan(i) $pc^{local}(t)$							0.05** (0.03)	
Coltan(i) X $pc(t)$	0.07** (0.03)	0.07** (0.03)	0.07** (0.03)	0.08** (0.03)	0.08*** (0.02)	0.06*** (0.02)	0.06*** (0.02)	0.10*** (0.02)
Coltan(i) X $pc(t-1)$		0.07** (0.03)	0.07** (0.03)	0.07** (0.03)	0.01 (0.01)	-0.00 (0.01)	0.00 (0.01)	
Coltan(i) X $pc(t-2)$			0.04 (0.03)	0.04 (0.03)	-0.02 (0.02)	-0.02 (0.02)	-0.01 (0.02)	
Coltan(i) X $pc(t-3)$				0.02 (0.03)	-0.03 (0.02)	-0.02 (0.02)	-0.00 (0.02)	
Constant	0.21*** (0.06)	0.10 (0.08)	0.03 (0.10)	-0.01 (0.11)	0.11** (0.05)	0.18*** (0.05)	0.20*** (0.05)	-0.20 (0.17)
Observations	2,951	2,951	2,951	2,951	2,724	2,497	2,497	2,724
R-squared	0.67	0.68	0.68	0.68				
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES	YES	YES
Sample	98-12	98-12	98-12	98-12	98-12	98-12	98-12	98-12
Number of sites					227	227	227	227

Notes: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Table 7 shows the estimates from a linear probability model with mining site and year fixed effects, regressing a dummy that indicates the presence of a stationary bandit on the lagged values of the  $C_i p_{c,t}^{US}$ . Columns (1)-(4) replicate the baseline specification, but include the lags. The coefficient on the first lag of  $C_i p_{c,t}^{US}$  suggests that the coltan demand shock led to the emergence of stationary bandits which persisted for two years after the shock, despite the sudden and permanent reversal of coltan demand in 2001. Column (5) adds the lagged dependent variable as a regressor and implements Arellano-Bond GMM estimation. Column (6) adds the second lag of stationary bandit and the results are unchanged. To rule out that continued local demand for coltan is accounting for the persistence of stationary bandits, Column (7) includes the average price of coltan paid by traders at the site level, collected in the survey. 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  $C_i p_{c,t}^{US}$  in order to circumvent endogenous location of stationary bandits. The results are unchanged, and the estimated impact of lagged stationary bandit on stationary bandit is close to 1.

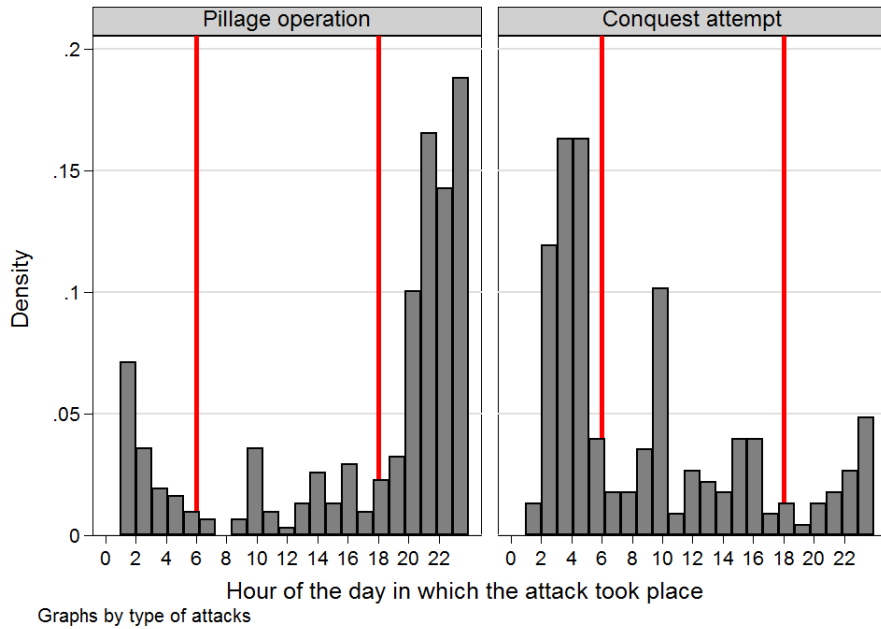
Table 8: Trajectories of state formation — minimalist vs administrative state

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Poll Tax	Village agricultural Market Tax	Village Mill Tax	Group administers village	Group rules	Group administers Justice	Group security is effective	Popular opposition
Coltan X pc	0.07* (0.04)	-0.00 (0.03)	0.02 (0.02)	-0.07** (0.03)	-0.04 (0.03)	-0.09** (0.04)	0.03 (0.04)	-0.01 (0.03)
Gold X pg	0.06 (0.04)	0.05 (0.03)	0.02 (0.02)	0.08** (0.03)	0.11*** (0.03)	0.09** (0.04)	0.01 (0.04)	0.07** (0.04)
Constant	0.10 (0.22)	-0.25 (0.19)	-0.36*** (0.11)	0.08 (0.19)	-0.13 (0.19)	0.08 (0.21)	0.66*** (0.22)	-0.11 (0.21)
Observations	1,167	1,003	1,176	1,176	874	1,176	1,176	1,176
R-squared	0.57	0.67	0.81	0.74	0.82	0.71	0.61	0.62
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES	YES	YES
Group FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Table 8 shows the estimates from a linear probability model at the support village with village and year fixed effects, regressing a dummy that indicates the type of governance on  $C_i$   $p_{c,t}^{US}$  and  $G_i$   $p_{g,t}^{US}$ . All regressions include within armed group fixed effect to explain the change in governance strategy by each armed group — thus ruling out group selection arising from coincidental timing of price shocks and the composition of groups.

# Online Appendix

Figure 12: Pillages and conquest attempt, by hour of the day



*Notes:* This figure shows the distribution of the hours at which the attacks take place in the sample.

## A Model

### A.1 A stateless economy

A village is composed of  $k$  of identical households,  $j = 1, 2, \dots, k$ . In what follows, I drop the household identifiers. Households are endowed with assets and choose the level of the following variables in  $n$  sectors  $i = 1, 2, \dots, n$ : labor supply, the amount of labor to hide, and the volumes of output to conceal from expropriation. Concealed output cannot be expropriated, and expropriation cannot be conditioned on hidden labor. Consider a mass of roving bandits. Roving bandits engage in uncoordinated expropriation of households' assets and output. When there are only roving bandits, households anticipate that their output will be expropriated at period 1 with probability one, and do not supply labor, a common pool problem among roving bandits.

At period 0, a bandit who has a higher endowment in the ability to exercise coercion might choose to impose his monopoly of violence in the village, at a fixed cost  $F$ , thereby acquiring the

option of becoming a stationary bandit.<sup>79</sup> The stationary bandit can announce his theft plan to households, a tax plan, in order to maximize his taxation revenue, although his plan may not be credible. The stationary bandit is a Stackelberg leader and households are uncoordinated followers. At the end of period 1, the bandit expropriates. If, at period 0, the strong bandit chooses to acquire the monopoly of violence, he may be able to sustain a relational contract with the households that allows him to credibly commit to his promise of theft. In that case, the stationary bandit announces how much he plans to steal (tax) in order to maximize his revenue, internalizing the static behavioral responses his tax generates.

## A.2 Taxation as a relational contract

It is immediate to see that if the interaction between the stationary bandit and the households was not repeated, absent social preferences, honoring the taxation plan cannot not be an equilibrium outcome: the bandit would be tempted to fully expropriate and the households would anticipate his pillage. Like pillage, taxation is expropriation. Unlike pillage, taxation implies commitment to a plan known to the households. Since households know the tax rate when they make choices, taxation cannot in general be full expropriation. I next motivate the modeling choice with interviews with armed actors, implemented in October 2013. 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 village. To settle in the village implies that we have to create relations on the village 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 village, we try to steal as much as possible. This is why the armed man is never friend if he finds no interest in it.”*

The above evidence suggests that relational contracts can be useful to explain the conditions under which taxation is sustained. Unable to sign formal contracts, bandits can use the value of the future to provide assurance to the population that they will respect the taxation plan.<sup>80</sup>

Suppose a bandit has been successful at establishing his monopoly of violence in the village. Assume the village has one sector, with nominal output  $y = pY$  and with output tax  $\tau$ . Let  $\tau^*$  be the feasible tax that would maximize the stationary bandit’s static tax revenue, if it was credible.

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<sup>79</sup>The fixed cost captures the costs incurred by attempting to conquer the village (waging troops, logistics), maintaining control of the village, and potentially, the costs of administering the village.

<sup>80</sup>If there was a state, the stationary bandit would be illegal, and since there is no state, the stationary bandit is the one creating and enforcing the law, hence lacks a credible commitment device.

If the bandit honors his taxation plan,  $T=1$ , and he obtains  $\tau^*y$ . If the bandit reneges on his taxation plan (he pillages),  $T=0$ , and he obtains  $y$ . The households 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  $M$ . If the bandit pillages and the households migrate, the bandit obtains  $R$  (roving value). Propositions 1 and 2 establish the conditions under which a taxation equilibrium exists. Let  $S$  denote the number of periods.

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

**Proposition 2.** *Let the game be infinitely repeated with exogenous probability of termination  $1 - \pi_s$ , discount factor  $\beta$ , and effective discount factor  $\tilde{\pi}_s = \beta\pi_s$ . A taxation Nash equilibrium exists, where the bandit plays  $T = 1$  if the household never migrated, and  $T = 0$  otherwise, and the household plays  $W = 1$  if the bandit never pillaged and  $W = 0$  otherwise if and only if:*

$$\frac{\tilde{\pi}_s R}{y} + 1 - \tilde{\pi}_s < \tau < 1 - \frac{M}{y}$$

A necessary condition is  $y \geq \bar{y} = R + \frac{M}{\tilde{\pi}_s}$ .

Proposition 2 bounds the static feasible tax. I next characterize the static optimal tax.

### A.3 Stationary bandit's optimal tax in a taxation equilibrium

The stationary bandit can tax output and labor, using respectively the taxes  $\tau = (\tau_1, \tau_2, \dots, \tau_n)$   $t = (t_1, t_2, \dots, t_n)$ . Households are partial residual claimants, and sell their output in the world markets at exogenous price  $p_i$  per unit of output. Output in sector  $i$ ,  $\tilde{Y}_i$ , is a function of real labor productivity in sector  $i$ ,  $\tilde{\alpha}_i$ , and the household's 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  $f(\tilde{\alpha})$ . Real productivities are known only after the household has supplied labor. Households' 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  $e = \sum_{i=1}^n e_i$ .

The households choose how much labor to supply to each sector  $e_i$ ,  $i = 1, 2, \dots, n$  and how much labor to hide from labor taxes  $e_i^H$ ,  $i = 1, 2, \dots, n$  before they observe output. Upon observing output, households choose the volume of output to conceal from taxes  $H_i$ ,  $i = 1, 2, \dots, n$ , given the sector tax on output  $\tau_i$  and the output price  $p_i$ . The value of output observable to the bandit

is  $\tilde{y}_i = (\tilde{\alpha}_i e_i - H_i) p_i$  and observable labor is  $\tilde{e}_i = e_i - e_i^H$ . The stationary bandit expropriates after households have allocated labor supply, hidden labor, and concealed output. The functions  $G^i(H_i, p_i)$  and  $E^i(e_i^H, p_i)$  are respectively the costs of concealing output and hiding labor. The two cost functions are differentiable, monotonically increasing in both arguments, ( $G_1^i > 0$ ,  $E_1^i > 0$ ,  $G_2^i > 0$ ,  $E_2^i > 0$ ) and strictly convex ( $E_{11}^i > 0$ ,  $G_{11}^i > 0$ ). The household's problem is:

The functions:  $e_i^*(p, F_\alpha, \tau, t)$ ,  $e_i^{H*}(p_i, t_i)$ ,  $H_i^*(p_i, \tilde{\alpha}_i e_i, \tau_i)$  are the solution to the household's

$$\begin{aligned} \max_{e, H; e^H} \quad & \int_{\tilde{\alpha}_1} \dots \int_{\tilde{\alpha}_N} u \left( \sum_{i=1}^N ((1 - \tau_i) p_i \tilde{\alpha}_i e_i + \tau_i p_i H_i - t_i \tilde{e}_i - G^i(H_i, p_i) - E^i(e_i^H, p_i)) \right) f(\tilde{\alpha}) d\tilde{\alpha}_1 \dots d\tilde{\alpha}_N - c(e) \\ \text{s.t.} \quad & H_i \leq \tilde{\alpha}_i e_i, \quad i = 1, 2, \dots, N \\ & e_i^H \leq e_i, \quad i = 1, 2, \dots, N \end{aligned}$$

FOC.<sup>81</sup> The stationary bandit chooses taxes to maximize his tax revenue subject to the household's participation constraint: Proposition 3 characterizes the stationary bandit's optimal tax at interior

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

solutions.

**Proposition 3.** *When labor tax is not available, interior solutions satisfy:*

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

where:  $\tilde{\varepsilon}_l^{y_i} = \frac{\partial \tilde{y}_i}{\partial (1 - \tau_l)} (1 - \tau_l)$  is the elasticity of observable output in the sector.<sup>82</sup>

Proposition 3 recovers Ramsey (1927)'s result: the optimal tax is inversely proportional to tax elasticity. This provides a justification for why the optimal tax on gold, easier to conceal, is lower.

<sup>81</sup>Figure 13 in the online appendix shows concealed volume as a function of realized output.

<sup>82</sup>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 Salanie (2011) and Piketty and Saez (2012).

## A.4 The choice to impose a monopoly of violence

This section provides conditions under which the bandit will choose to incur the fixed cost  $F$  in order to establish a monopoly of violence in the village,  $s_b = 1$ , or remain roving,  $s_b = 0$ . If the bandit acquires the monopoly of violence, he has the option to sustain a relational contract of taxation with the population, so long as the tax that he proposes can be sustained as a self-enforcing equilibrium. Let  $V_s$ , and  $R$  be respectively the expected per period revenue when the bandit chooses to establish the monopoly of violence, or remain roving. Let  $\pi_s(s_b; s_{-b}) \in [0; 1]$  be a contest success function for property over the monopoly of violence, such that:  $\pi_s(s_b; 0) = 1$ ,  $\pi_s(0; s_{-b}) = 0$  and  $\pi_s(1; 1) = \pi_s$ . If the monopolist of violence is overthrown, his payoffs terminate. I focus on monopolies of violence where taxation can be sustained as a relational contract, otherwise the asset value of acquiring the monopoly of violence is identical to roving. Let  $F$  be the cost of acquiring the village monopoly of violence and  $\beta \in [0; 1]$  the time preference.

**Proposition 4.** *The bandit will choose to impose a monopoly of violence if and only if the present discounted value of his expected payoff as a stationary bandit is larger than under roving banditry:*

$$\frac{\pi_s(1; s_{-b})}{1 - \pi_s(1; s_{-b})\beta} V_s - F > \frac{R}{1 - \beta}$$

## A.5 “Gold is immaterial: we never see it.”

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 advanced monitoring technology, concealing gold is costless (Geenen, 2013).<sup>83</sup> I next provide sufficient conditions for the output tax in the gold sector to be exactly zero, so as to match the empirical evidence. Let  $i = g$  denote the gold sector. Let  $\underline{H}_i \in R$  such that  $\forall H_i < \underline{H}_i$ ,  $G_1^i(H_i, p_i) = 0$ . Let  $\bar{\alpha}_g = \sup\{A_g\}$ , where  $A_g$  is the set of gold real labor productivity realizations. Assumption G1 is  $\bar{\alpha}_g L \leq \underline{H}_i$ . Let  $T_i$  be the fixed cost of taxing output. Assumption G2 is  $\tau_g^* p_g \int (\tilde{\alpha}_g e_g - H_g) dF_g(\tilde{\alpha}_g) < T_g$ .

**Proposition 5.** *Sufficient conditions for the tax on output to be exactly zero,  $\tau_i^* = 0$  are either i) Assumption G1, in which case  $\forall \tau_i > 0$ ,  $H_i^* = \tilde{\alpha}_i e_i$  or ii) Assumption G2, in which case  $\tau_i^* = 0$ .*

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<sup>83</sup>Anecdotal evidence from gold mines located elsewhere shows that employers frequently use X-rays to monitor gold miners. See: [http://factsanddetails.com/world.php?itemid=1235 & subcatid=324](http://factsanddetails.com/world.php?itemid=1235&subcatid=324): “Workers at the end of their shift are ushered into a corridor surrounded by glass and monitored by video cameras. Security guards carefully pick through the workers clothes and give them random full body X-ray.”

## A.6 Testable implications: effects of price shocks

Having presented the model, I now derive testable implications for the effect of rising output price on taxation, stationary bandits, and battles between stationary bandits. In what follows, I assume a village is endowed with one sector, with non-stochastic output, and that only one bandit can establish a monopoly of violence. Proposition 6 provides sufficient conditions for the effect of a rise in the output price on the likelihood of taxation.

**Proposition 6.** *Emergence of taxation. If  $-\frac{\tilde{\pi}_s R}{y} \epsilon_p^y < \frac{\partial \tau^*}{\partial p} < \frac{M}{y} \epsilon_p^y$ , a rise in the output price  $p$  increases the range of parameters consistent with a taxation relational contract. A sufficient condition for  $-\frac{\tilde{\pi}_s R}{y} \epsilon_p^y < \frac{\partial \tau^*}{\partial p} < \frac{M}{y} \epsilon_p^y$  is that labor supply is isoelastic, in which case  $\frac{\partial \tau^*}{\partial p} = 0$ .*

*Proof.* From  $\frac{\tilde{\pi}_s R}{y} + 1 - \tilde{\pi}_s < \tau^* < 1 - \frac{M}{y}$ , the left hand side is decreasing in  $p$  and the right hand side is increasing in  $p$ .  $\square$

I now examine the impact of the output price on the emergence of stationary bandits. Proposition 7 establishes the result when there is only one contender.

**Proposition 7.** *Emergence of stationary bandits. A rise in the output price  $p$  increases the profits of a stationary bandit:  $\frac{\partial V_s}{\partial p} > 0$ . Proof in online appendix.*

Allow multiple bandits to compete over the monopoly of violence,  $\pi_s(s_b; s_{-b}) \in \{0; \pi\}$ . Proposition 8 examines the effect on contestation.

**Proposition 8.** *Intensification of battles between bandits.  $\exists p^S, p^W \in R$ ,  $p^S < p^W$  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.*

Proposition 9 examines how these effects compare across villages whose endowments vary in the cost of concealing output, comparing gold and coltan villages.

**Proposition 9.** *Heterogeneous effects by cost of concealing output. Let  $G^i(H_i, p_i) = \frac{ph}{2} H_i^2$ . The effect of a price increase on the gains of the stationary bandit are larger when hiding output is costlier for the household,  $\frac{\partial^2 V_s}{\partial p \partial h} > 0$ . Furthermore, the effect of a price increase is larger for coltan than gold:  $\frac{\partial V_s}{\partial p_c} - \frac{\partial V_s}{\partial p_g} > 0$ . This result holds under general functional forms for  $G^i(H_i, p_i)$ .*



Finally, it is straightforward to see that where trade costs are arbitrarily high, the local price obtained for one unit of mineral will be zero, independently of global changes in demand as long as demand shocks are not too large so as to render the trade costs affordable. Hence, for coltan villages who are far from airports, fluctuations in global demand should leave the incentives of stationary bandits unaffected.

## A.7 Households' first order conditions

There are  $N$  First order conditions for  $e_i$ ,  $N$  First order conditions for  $e_i^H$ ,  $N$  first order conditions for  $H_i$  conditioned on  $\tilde{\alpha}_i e_i$  plus the  $N + 1$  first order conditions from the constraints. The Kuhn-Tucker conditions with respect to  $H_i$ ,  $i = 1, \dots, N$  give:

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

and

$$\tau_i p_i - G_1(H_i, p_i) \geq 0 \quad i = 1, \dots, N$$

An interior solution is therefore given by  $H_i < \tilde{\alpha}_i e_i$  and  $H_i > 0$ , hence  $\mu_i = 0$  and:

$$\tau_i p_i = G_1(H_i, p_i)$$

Similarly, 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 FOC with respect to  $e_i$ ,  $i = 1, \dots, N$  give:

$$\int (u'[(1 - \tau_i)p_i \tilde{\alpha}_i - t_i] + \mu_i) dF(\alpha) - \lambda - c'(e_i) = 0, i = 1, \dots, N$$

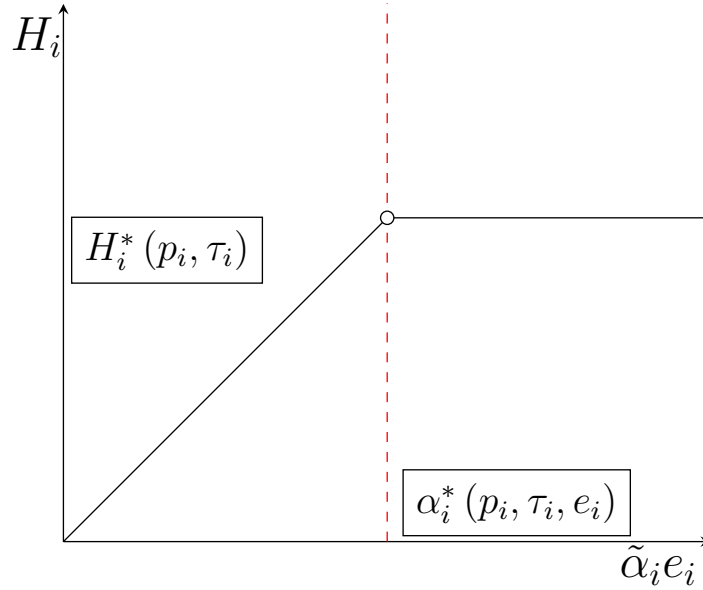
for sectors where the hiding constraint is binding, and:

$$\int (u'[(1 - \tau_i)p_i \tilde{\alpha}_i - t_i]) dF(\alpha) - \lambda - c'(e_i) = 0, i = 1, \dots, N$$

for sectors where it is not.

## A.8 Optimal volume hidden

Figure 13: Labor real productivity and volume hidden by households



*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 household's first order conditions. If the realized labor real productivity is below a certain threshold, the household is at a corner solution and hides all output. If the realized labor real productivity is above the threshold, the volume hidden is an interior solution.

## A.9 Proof of proposition 5

Suppose there is only one sector, so I drop the sector identifiers  $i$ . Let  $G(H, p) = k \frac{H^2}{2}$ . The 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:  $\tau^* = \frac{1}{2} \frac{1}{\alpha^2 + \frac{1}{\alpha^{2k}}}$ . 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, and  $k = +\infty$ ,  $\tau^* = \frac{1}{2}$ . This is because labor supply is isoelastic and always equal to 1, which can be seen from the inverse elasticities rule. If  $k \in \mathbb{R}^+$ ,  $0 < \tau^* < \frac{1}{2}$ . When  $\alpha$  is large  $\tau^*$  approaches its upper bound, and when  $\alpha$  is small,  $\tau^*$  tends to 0. Since  $\bar{\alpha}_g \approx 0$ , the optimal tax in a village where the only sector is gold will be low. Furthermore, if  $\bar{\alpha}_g$  is sufficiently low so that  $\bar{\alpha}_g L < \underline{H}$  (assumption G1), 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:

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

which is strictly increasing in  $\alpha$ . Therefore,  $\exists \underline{\alpha}$  s.t.  $\forall \alpha < \underline{\alpha}$ ,  $R(\alpha) \leq F_g$ ,  $\tau^* = 0$  and  $\forall \alpha > \underline{\alpha}$ ,  $R(\alpha) > F_g$ ,  $\tau^* > 0$  where  $F_g$  was defined as the fixed cost of levying an output tax in the gold sector.

## A.10 Proof of propositions 7 and 9

Let  $\tilde{e} = e_i - e_i^H$  the observable labor input,

$$\frac{\partial E_\alpha V}{\partial p_c} = \tau_c E \alpha_c \left( e_c + p_c \frac{\partial \tilde{e}_c}{\partial p_c} \right) + \frac{\partial \tilde{e}_c}{\partial p_c} t_c > 0,$$

and

$$\frac{\partial E_\alpha V}{\partial p_g} = \frac{\partial \tilde{e}_g}{\partial p_g} t_g > 0$$

A rise in the output price in one location increases the value of choosing stationary bandit in that location through three channels: it raises the value of each unit of output output taxed; it increases the units of output taxed (if the income effect on labor supply is smaller than the substitution effect); and it increases the amount of labor taxed. In gold villages, only the third channel affects the value of holding a monopoly of violence. Let  $c(e) = \frac{1}{2}e^2$ ,  $E(e_H) = \frac{c}{2}e_H^2$   $G(H, p) = \frac{ph}{2}H^2$  for simplicity. The household's and the bandit's programs are now, respectively:

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

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

The optimal taxes are  $\tau^* = \frac{1}{2} \frac{1}{1+s}$  and  $t^* = \frac{\alpha p}{2} \frac{c}{1+c} \frac{s}{1+s}$ , where  $s = \frac{1+c}{p\alpha^2 h}$ . Applying the Envelope theorem to the bandit's objective function, it follows that:

$$\frac{\partial V}{\partial p} = \frac{\alpha^2 p}{(1+s)^2} \left( \frac{1}{2} + s \frac{3+4c}{1+c} + \frac{s^2}{2} \frac{c}{1+c} \right) > 0$$

This establishes proposition 2. It is then straightforward to show that an increase in the cost of hiding output impacts the tax revenue of the bandit positively:

$$\frac{\partial^2 V}{\partial p \partial h} = \frac{\partial^2 V}{\partial p \partial s} \frac{\partial s}{\partial h} = \frac{(1+c)^2}{4h^2} \frac{1 + \frac{3}{4}s}{(1+s)^3} > 0$$

This establishes proposition 3 when  $\alpha_g = \alpha_c$  and  $p_g = p_c$ . Let us now allow  $\alpha_g \neq \alpha_c$  and  $p_g \neq p_c$ . For gold, there is no tax on output, therefore:

$$\frac{\partial V}{\partial p_g} = \frac{\alpha_g^2 p}{2} \frac{c}{1+c}$$

We then have:

$$\begin{aligned} \frac{\partial V}{\partial p_c} - \frac{\partial V}{\partial p_g} &= \frac{\alpha_c^2 p_c}{(1+s)^2} \left( \frac{1}{2} + s + \frac{s^2}{2} \frac{c}{1+c} \right) - \frac{\alpha_g p}{2} \frac{c}{1+c} \\ &= \frac{1}{2} \frac{\alpha_c^2 p_c}{(1+s)^2} (1+2s) \left( 1 - \frac{c}{1+c} \frac{\alpha_g^2 p_g}{\alpha_c^2 p_c} \right) \end{aligned}$$

As already established, this is positive if  $\alpha_g = \alpha_c$  and  $p_g = p_c$ . When  $\alpha_g \neq \alpha_c$  and  $p_g \neq p_c$ :

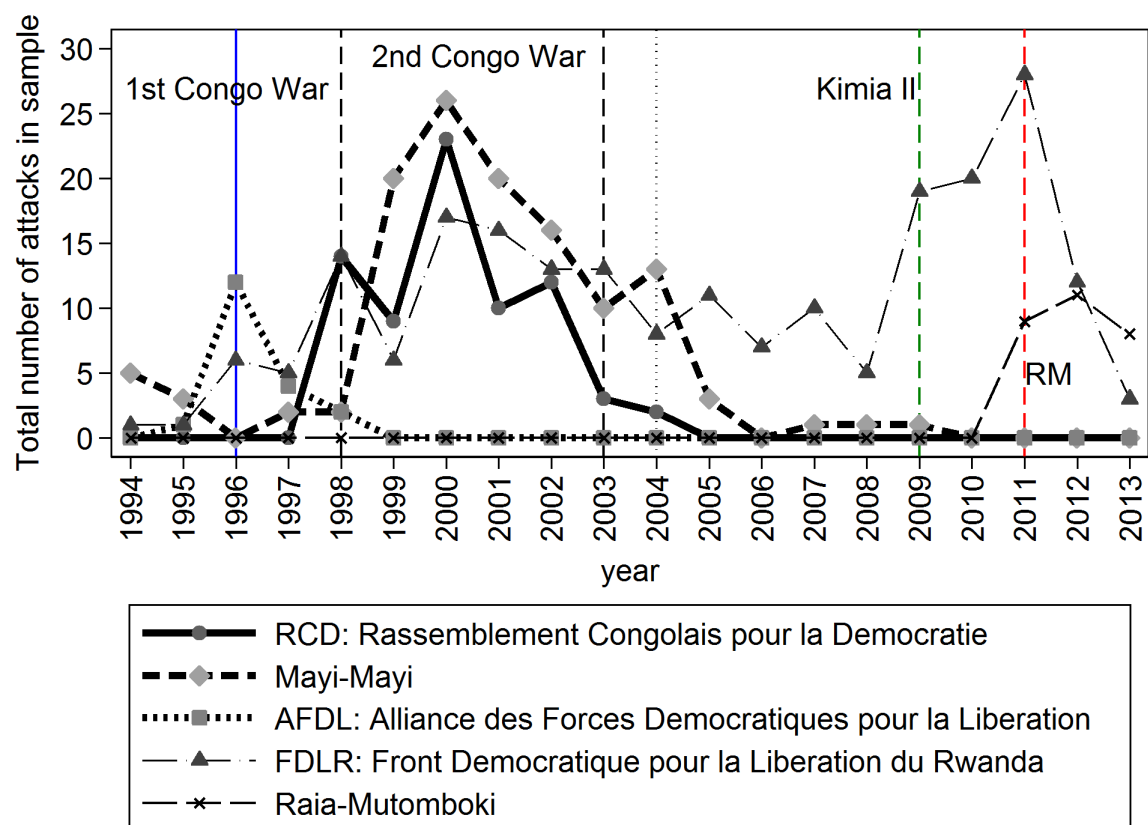
$$\begin{aligned} \frac{\partial V}{\partial p_c} - \frac{\partial V}{\partial p_g} &> 0 \\ &\Leftrightarrow \\ c &> \frac{1}{r-1} \end{aligned}$$

where  $r = \frac{\alpha_g^2 p_g}{\alpha_c^2 p_c}$ . Parametrizing the labor productivity and prices of coltan in units of grams (per day) and dollars per gram produced with the values of 1999, we have  $r = .000004$ , thus this condition holds for all values of  $c$ . I can go a step further and rescale the partial derivatives, dividing them  $\alpha_g^2 p_g$  and  $\alpha_c^2 p_c$ . It is straightforward to show that  $\frac{\partial V}{\partial p_c} - \frac{\partial V}{\partial p_g}$ . In an extension, I use this property to re-scale the estimated partial effects and my results remain. This analysis assumed a cost of hiding function that increases linearly in prices. This assumption is not a necessary condition and was chosen for simplicity of exhibition. If, rather than the possibility of tax evasion, I used instead the stochastic nature of real productivity, one can derive the same result. When

output is uncertain, the optimal tax is a risk sharing contract. Therefore, the impossibility to use the tax on output generates a welfare loss stemming from the fact that the bandit has less instruments to absorb risk from risk averse households.

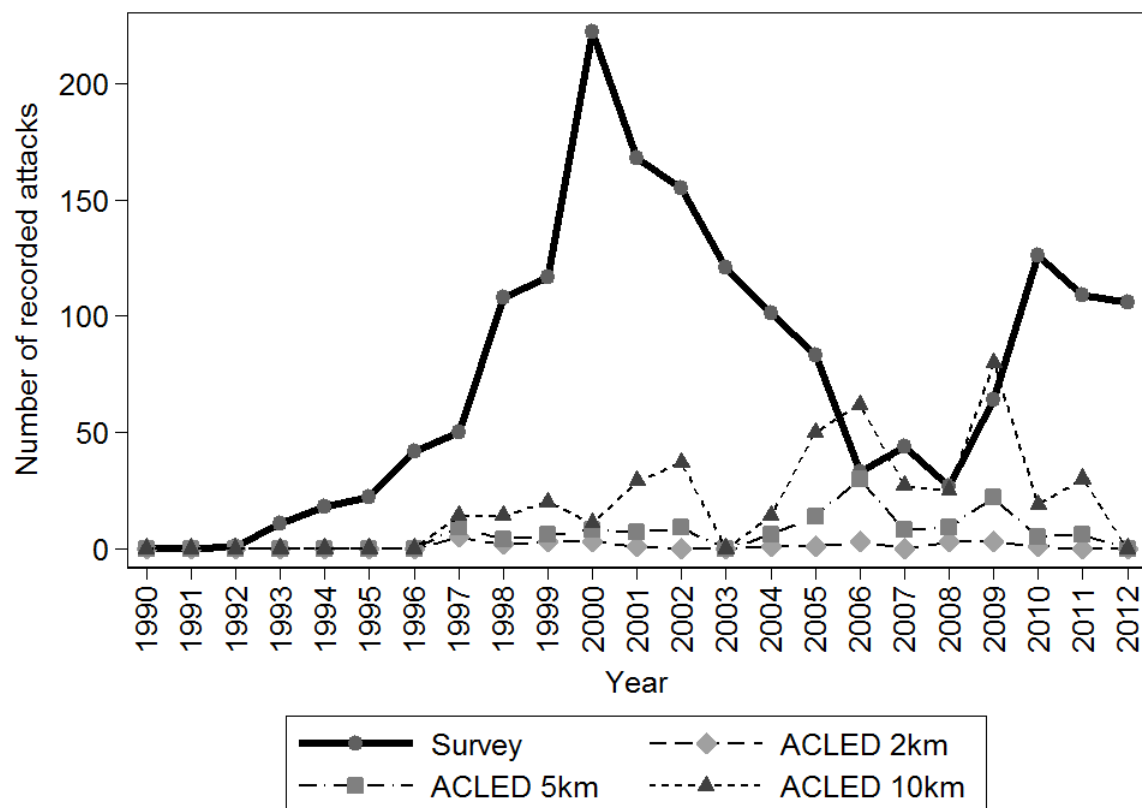
## **B   Validation of the data**

Figure 14: Recorded violent Events and 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. The thin dotted line indicates attacks by the AFDL, the thick solid black line indicates attacks by the RCD, the black thick dashed line indicates the number of attacks by the Mayi-Mayi's, the thin dashed line with triangles indicates the number of attacks by the FDLR and the thin dashed line with crosses indicates the number of attacks by the Raia Mutomboki. Correspondingly, the vertical blue line at 1996 marks the period of the AFDL rebellion as known from history; the black vertical dotted lines at 1998 and 2003 bound the Second Congo War; the vertical dotted line indicates the date of the CNDP offensive, the green vertical dashed line at 2009 marks the Kimia II military intervention, which resulted in massive pillage operations by the FDLR to acquire resources as their financial base was being disrupted, and the red vertical dashed line at 2011 indicates the known year of the emergence of the Raia Mutomboki. While the number of recorded attacks is larger in the data, the source used in this figure is the attacks module, which focuses on the details of the major attacks on the village, and which has extensive details about the attack (perpetrator identity, group size, hour of the attack, activities in village, types of violence and amounts stolen).

Figure 15: Recorded violent Events and ACLED violent events



*Notes:* This figure plots the number of attacks on the sample villages I recorded in the survey, as well as the number of attacks recorded by ACLED which are located in the neighborhood of the survey villages. I represent the total number of attacks recorded in the survey with the solid line, and the number of attacks recorded from ACLED in the neighborhood of my survey villages with the dashed lines, for different perimeters around the villages. To assign battles recorded by ACLED to the survey villages, I computed the number of geo-located ACLED battles that were located within a given perimeter of the survey 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 to 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 Congolese Army (see Sanchez de la Sierra (2014)). In contrast to the survey data, the geo-referenced ACLED dataset does not capture these trends, 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 9: Survey and ACLED battles

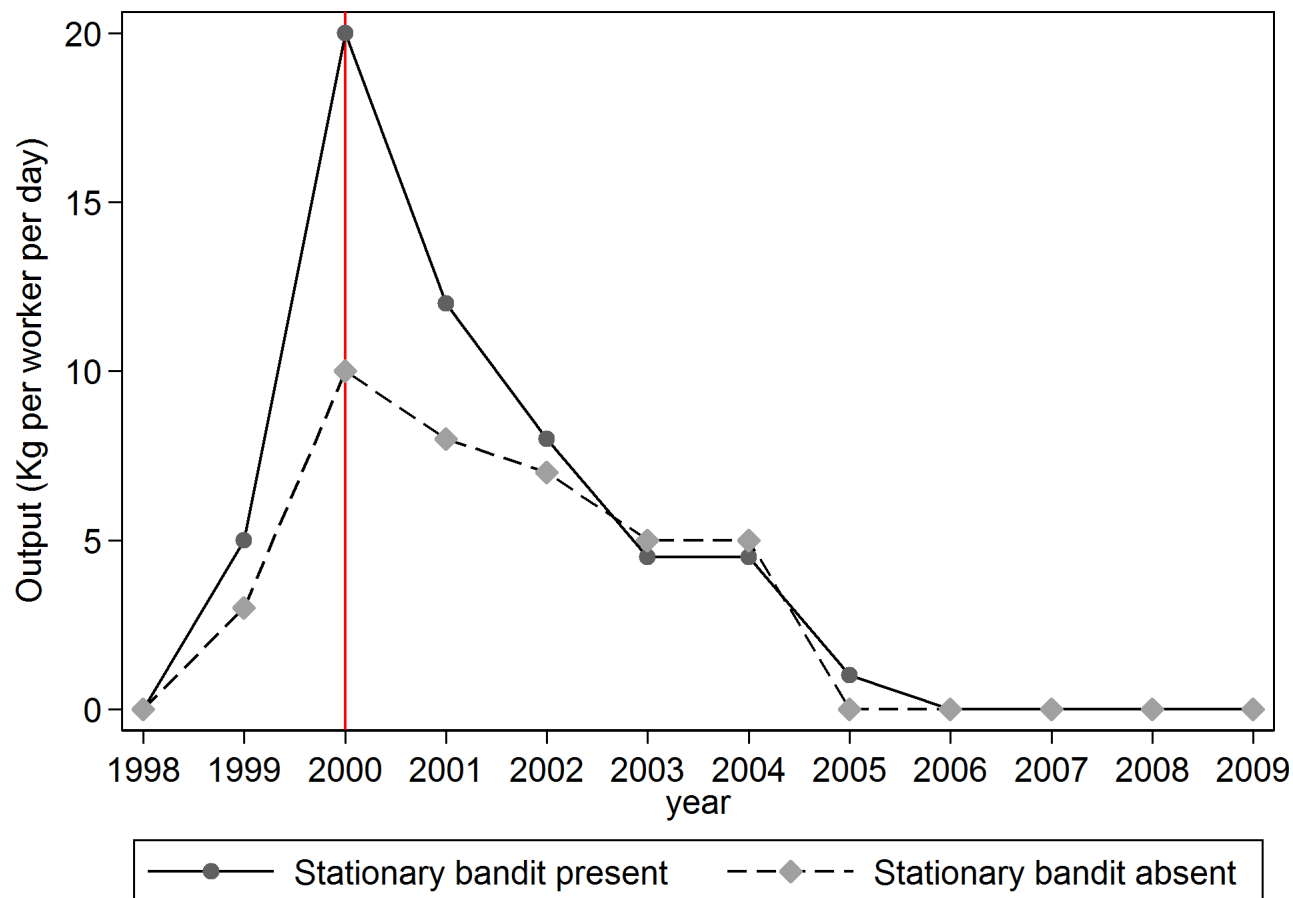
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	1 km	2 km	5 km	10 km	15 km	20 km	25 km	50 km
Conquest attempts, survey	0.0132*** (0.00381)	0.0281*** (0.00650)	0.0534*** (0.0103)	0.0652*** (0.0161)	0.0970*** (0.0224)	0.0976*** (0.0258)	0.133*** (0.0280)	0.117*** (0.0347)
Constant	0.00712* (0.00368)	0.0292*** (0.00628)	0.0510*** (0.00996)	0.0807*** (0.0156)	0.125*** (0.0217)	0.200*** (0.0249)	0.244*** (0.0271)	0.606*** (0.0335)
Observations	2,128	2,128	2,128	2,128	2,128	2,128	2,128	2,128
R-squared	0.107	0.132	0.145	0.172	0.232	0.272	0.283	0.398

*Notes:* \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . This table presents the results on the OLS regression of battles recored by ACLED on battles recorded in the survey. To assign battles recorded by ACLED to the survey villages, I computed the number of geo-located ACLED battles that were located within a given perimeter of the survey village. From left to right, columns (1) to (8) report the results using the number of events of ACLED near the village using circles 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\*year level.

## C Additional results

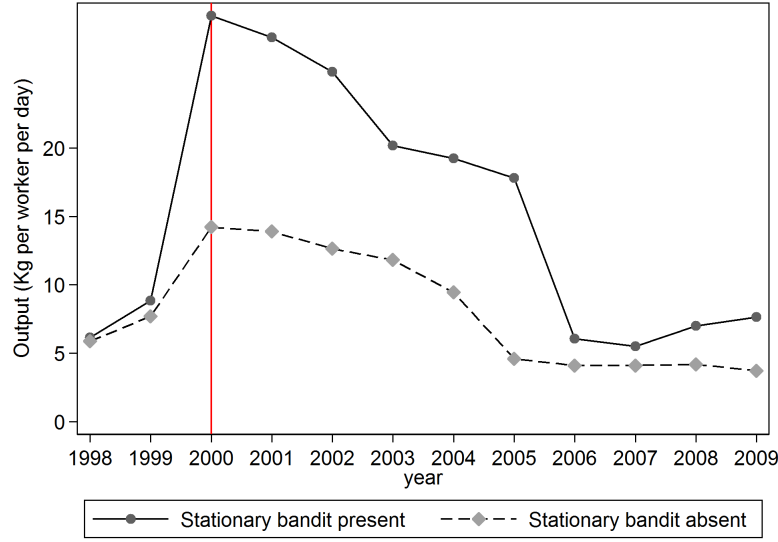


Figure 16: Coltan demand shock, stationary bandits and median production



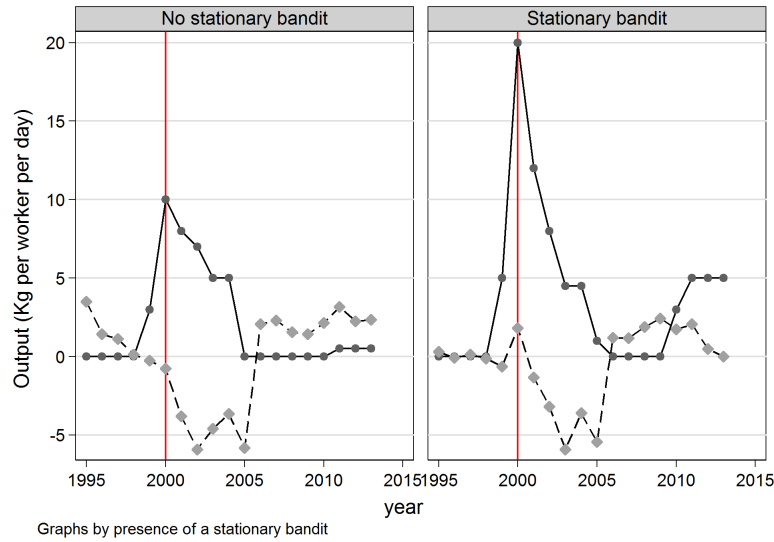
*Notes:* This figure plots the median coltan production on year, for mining sites in which a stationary bandit was present in 2000, and for mining sites in which a stationary bandit was not present in 2000. A stationary bandit is defined as an armed actor who holds the monopoly of violence in a given site for at least 6 months (approximately). The solid line graphs the median output (in Kilograms per worker per day) in coltan sites where a stationary bandit is present, the dotted line for sites where a stationary bandit is not present. I report the median production instead of the mean production because outliers inflate the effect in my favor when I use mean production. In the online Appendix, I also report the mean production.

Figure 17: Coltan demand shock, stationary bandits and mean production



*Notes:* This table replicates Figure 16 using mean production instead of median production. In the main text, I used median production to prevent outliers from driving the result, given the presence of outliers. The figure shows that average production is much more affected by the coltan shock in mining sites where a stationary bandit was present, suggesting that there are complementarities between the presence of a stationary bandit and production, consistent with the value of the protection they provide.

Figure 18: Coltan demand shock, stationary bandits and median production controlling for geography



*Notes:* This table replicates Figure 16 and also reports the residuals from regressing production on year dummies interacted with an indicator for whether the corresponding support village is located far from a local airport. I control for airport distance year dummies since stationary bandits may have just chosen to locate in the best coltan mining sites, near airports where the coltan can be shipped cheaply, thus generating a selection effect. Even after controlling for the airport distance year dummies, which proxy for the profitability of the coltan minin site, the effect of the coltan demand shock on production is concentrated in mining sites where a stationary bandit is present, suggesting that there are complementarities between the presence of a stationary bandit and production, consistent with the value of protection they provide..

## D Additional Robustness Tests

I implement five strategies to increase confidence in the main OLS estimates.

First, I replicate the baseline specification for all variables using conditional logistic regressions instead, since in the presence of errors in variables, linear probability models could be biased (Hausman, 2001). Table 10 reports the results in columns (1), (2), (3) for the three main outcome variables (stationary bandit, conquest, taxation). The results are unchanged.

Second, I account for the observation that conquest attempts are rare events. In that case, OLS estimation could lead to biases in the estimated probabilities and standard errors (King and Zeng, 2001). I therefore run a logistic version of the baseline specification which corrects for a small sample and rare events in order to generate approximately unbiased and lower-variance estimates, as introduced in King and Zeng (2001). Table 10 reports the results in columns (4), (5), (6). The results are unchanged.

Third, I account for the fact that while some sites may be sufficiently “urbanized” and thus have the amenities for stationary bandits, other sites may not. It is thus logical to expect stationary bandits to be less likely to respond to the price shocks in mining sites that are not urbanized. To measure urbanization, I collect information on each site on whether villagers of the support village are involved in the following activities: beer retail, hotel industry, prostitution, mineral trading, or other business (water, for instance, is a profitable business in urbanized mining sites). Table 11 replicates the baseline specification separating sites which are urban from sites which are not. Consistently across outcome measures, most of the armed actors’ response to the price shocks is concentrated in sites which are urban.

Fourth, I account for the problem of spatially correlated distances and errors which may lead to bias in the estimation of the standard errors if not correctly accounted for. Distance to the closest airport is similar for villages in the proximity, which are also likely to share common economic and social shocks due to their proximity to airports. Support villages that are close to airports, *even if they are close to different airports*, may experience similar shocks if they are better integrated in the regional and world economy. I use randomization inference, which allows me to avoid making assumptions about the distribution of the error term. I tackle different problems with different assignment processes in turn.

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 simulated endowments whose value is larger than the value estimated using the real endowments. Figure 20 shows the resulting distribution. As expected, 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 20 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, anyways, is 0.0001. I finally proceed by using 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 21 shows the resulting reference distribution and the corresponding p-value, and the results are analogous.

Fifth, I implement conditional differences-in-differences matching, introduced by Heckman, Ichimura, and Todd (1998), and the results remain.<sup>84</sup>

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<sup>84</sup>This method is similar in spirit to case control methods, presented in Goldstone, Bates, Epstein, Gurr, Lustik, Marshall, Ulfelder, and Woodward (2010), where I select observations based on whether I observe coltan endowment and then select matches. As matching variables, I use distance to airports and to roads, as well as upper level administrative divisions (Territoire). Finally, to control for constant unobserved heterogeneity across regions (Territoires), I also match on Territoire. This procedure is thus equivalent to conditional differences-in-differences within calipers defined by administrative divisions (Cochran and Rubin, 1973). I do not report this result here but it is available upon request.

Table 10: Replication with conditional logit and Rare Events Logistic Regression (King and Zeng, 2001)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Stationary Bandit	Attacks Conquest	Taxation Any type	Stationary Bandit	Attacks Conquest	Taxation Any type
Coltan(i) X pc(t)	0.35* (0.21)	0.70** (0.31)	0.76** (0.38)	0.36*** (0.14)	0.71*** (0.20)	0.79** (0.31)
Constant	-0.11 (0.17)	-1.52*** (0.30)	-1.83*** (0.35)	-0.11 (0.27)	-1.55*** (0.37)	-1.88*** (0.38)
Observations	454	260	242	454	260	242
Year FE	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES
Model	LOGIT	LOGIT	LOGIT	RELRL	RELRL	RELRL
Sample	99-00	99-00	99-00	99-00	99-00	99-00

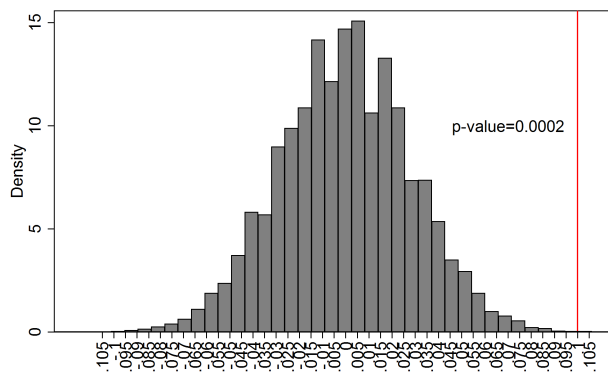
Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. This table uses alternative specifications to replicate the results of the linear probability model for the outcomes *stationary bandits*, *attempted conquests*, *taxation*. A stationary bandit is defined as an armed actor who holds the monopoly of violence in a given site for at least 6 months (approximately). The baseline linear probability model was  $Y_{it} = \beta_t + \alpha_i + \gamma_c \text{Coltan}_i pc_t + \varepsilon_{it}$  where  $\text{Coltan}_i$  is a dummy indicating whether site i is endowed with available coltan, which is constant over time,  $pc_t$  is the logarithm of the US price of coltan, and  $\beta_t$  and  $\alpha_i$  are year and site fixed effects. Columns (1) to (3) present the results using a conditional logit regression with support village and year fixed effects instead. Columns (4) to (6) present the results using rare events logistic regression, as developed by (King and Zeng, 2001), in order to account for the possibility that small number of successes among the dependent variables leads to a rare event bias.

Table 11: Replication of the main result, separating urban mining settlements from non-urban

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Stationary Bandit	Turnover	Mine Taxes	External Attacks	Stationary Bandit	Turnover	Mine Taxes	External Attacks
Coltan(i) X pc(t)	0.09** (0.04)	0.15*** (0.05)	0.19*** (0.05)	0.13** (0.06)	0.05 (0.06)	0.06 (0.07)	0.13** (0.06)	0.13** (0.06)
Constant	0.45*** (0.07)	-0.09 (0.09)	-0.09 (0.11)	-0.08 (0.12)	0.13 (0.11)	0.00 (0.11)	-0.16 (0.15)	-0.28* (0.16)
Observations	308	308	182	174	166	166	78	68
R-squared	0.87	0.46	0.85	0.72	0.84	0.44	0.80	0.60
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES	YES	YES	YES
URBAN	YES	YES	YES	YES	NO	NO	NO	NO
Sample	99-00	99-00	99-00	99-00	99-00	99-00	99-00	99-00

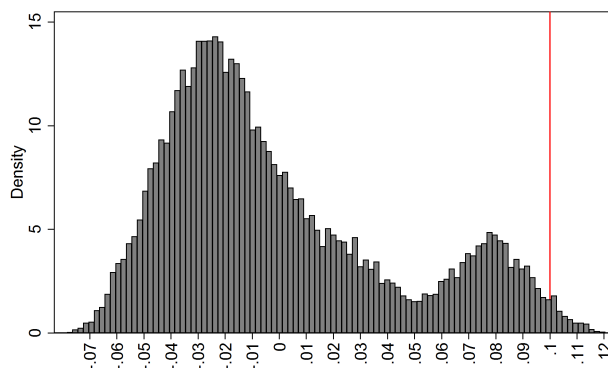
Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. This table uses alternative specifications to replicate the results of the linear probability model for the outcome *stationary bandits*. A stationary bandit is defined as an armed actor who holds the monopoly of violence in a given site for at least 6 months (approximately). The baseline linear probability model was  $Y_{it} = \beta_t + \alpha_i + \gamma_c \text{Coltan}_i pc_t + \varepsilon_{it}$  where  $\text{Coltan}_i$  is a dummy indicating whether site i is endowed with available coltan, which is constant over time,  $pc_t$  is the logarithm of the US price of coltan, and  $\beta_t$  and  $\alpha_i$  are year and site fixed effects. Columns (1) to (3) present the results conditioning the sample on mining sites that are urban. Columns (4) to (6) present the results conditioning the sample to non-urban mining sites. While the effects seem to be concentrated among urban mining sites, the sample size for non-urban sites is very small.

Figure 19: Randomization inference, results from 20,000 simulated coltan endowments



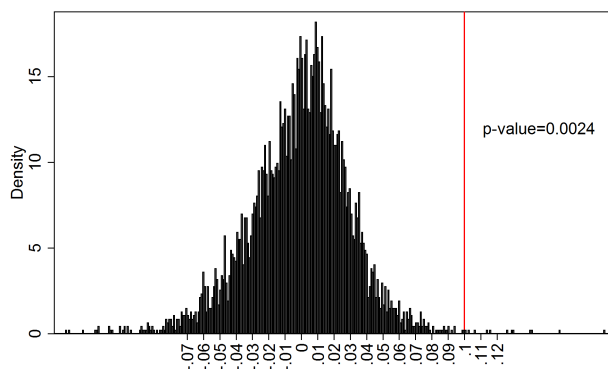
*Notes:* The figure presents the distribution of coefficients estimated using the simulated coltan endowments. To obtain a p-value using the new reference distribution, I compute the mass of coefficients derived from the simulated endowments whose value is larger than the value estimated using the real endowments.

Figure 20: Randomization inference, results from 20,000 simulated assignment of observed prices



*Notes:* 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. The resulting distribution is bi-modal and centered below zero because one of 12 prices is an outliers (the price that really occurred in 2000).

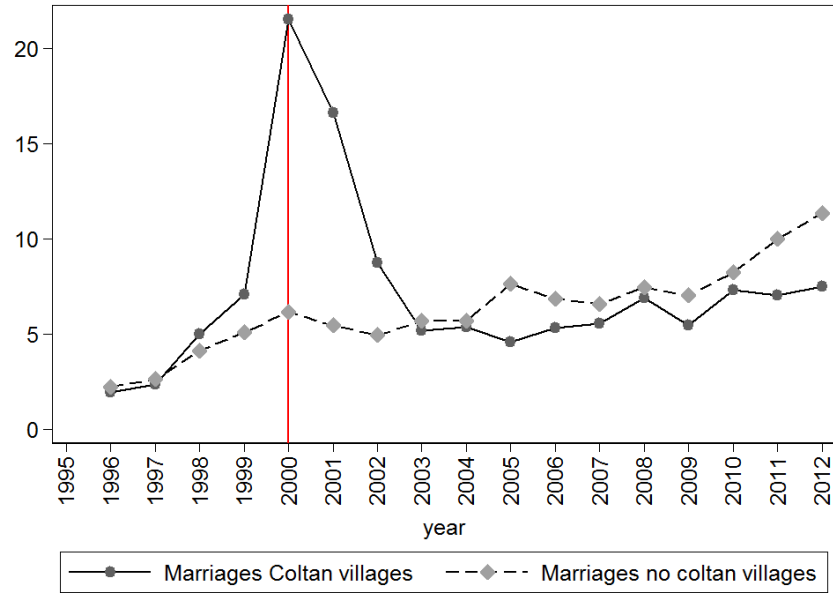
Figure 21: Randomization inference, results from 20,000 simulated assignment of theoretical prices



*Notes:* 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.

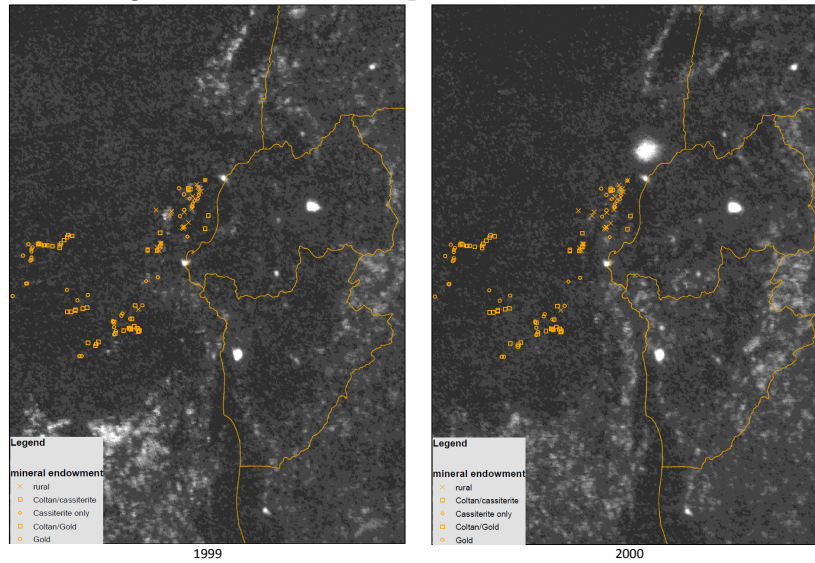
## E Validation of the coltan shock

Figure 22: The coltan demand shock and the demand for marriage



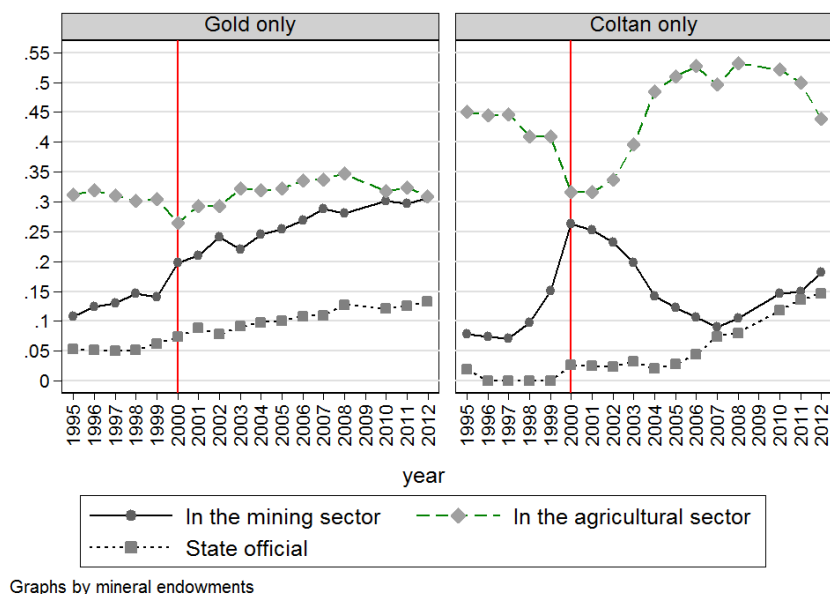
*Notes:* This figure plots the average number of recorded marriages in the survey support villages by year. The solid line indicates the average number of marriages in coltan support villages, by year. The dashed line indicates the average number of marriages in support villages without coltan sites, by year.

Figure 23: The coltan price shock from satellite



*Notes:* This figure presents satellite imagery of the survey area at night. 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 Democratic Republic of Congo is on the left of the vertical line, and from North to South are Uganda, Rwanda, Burundi, Tanzania on the right of the line. The major mineral endowments of the sites attached to each support villages are as indicated in the figure legend. In the year 2000, town lighting increases in the northern part of the picture, bordering Rwanda, which is the area around Goma, the trading hub for coltan trade. As the price of coltan boomed, economic activity increased around Goma.

Figure 24: The coltan demand shock and labor supply



*Notes:* This figure plots the proportion of respondents of the household survey who work in a given 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.

## F Expectations about future prices

First, if villagers anticipated the coltan shock, estimates of the coltan shock may reflect a lower bound of the real effect. For instance, groups could have fought for monopolies of violence in coltan villages in 1999 knowing that the price would rise in the future. Second, following the price increase, if local populations anticipated that the shock was going to be short-lived then the estimates of the effect of the shock underestimate the real effects of permanent price shocks, especially if groups' cost functions have non-convexities. Third, following the sudden price drop in international markets, the persistence of the effects of the coltan shock is overestimated if populations expected the price would rise back to the level it reached during the year 2000 spike.

There is significant anecdotal evidence on expectations about the coltan price level - most people in the Kivus remembered very well the coltan shock. This anecdotal evidence has three implications. First, unanticipated innovations in the electronics markets led to the rush to coltan. Second, this demand for coltan vanished when Playstation II performed poorly for unexpected reasons in the year 2000 Christmas market. It is therefore very unlikely that local populations expected a sudden drop in demand for this mineral. Third, following the sudden price drop in



2001, local traders hoarded minerals because they expected the world demand to rise back to its peak level of 2000.<sup>85</sup> In addition, I collected retrospective measures of expectations held by the villagers in this survey. Villagers expected neither the increase nor the decrease in prices.

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<sup>85</sup>United Nations Security Council (2002).