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Abstract

The actions of terrorist groups destabilize border states and economies. The presence of mining activities, such as gold extraction, favors the illicit export of this ore to finance terrorist groups. Using COMTRADE data, we estimate gold customs fraud with mirror analysis (gold export missing) for 50 African countries between 2000 and 2019. We use ordinary least squares, two-stage least squares, generalized method of moments, and local impulse strategy in our empirical strategies to estimate the impact of terrorism on gold customs fraud. Our results suggest that states affected by terrorism must pay more attention to the trafficking of gold, as this is a valued mineral for terrorist groups. The response to conflict with terrorist groups cannot be solely military. The State must necessarily get the various state services to work together, particularly the army, the police, and customs. The institutionalization of this cooperation remains a real challenge for these states. Regarding customs administration efficiency, data analysis is at the core of customs modernization programs. Only internal and external trade data have been used in risk management systems. Cooperation with the armed forces must allow the acquisition of tools and skills to analyze other data sources, such as satellite data. Customs could then carry out all of its missions at the borders: collecting duties and taxes but also protecting the local/border economy and cutting off the funding sources for terrorist groups.

Keywords

Customs fraud, Terrorism, Mirror analysis, Gold, Performance of customs administration

JEL Codes

D73, F14, H83, O17, Q34, Q38

1. Introduction

Many African countries are destabilized by extremist groups through the use of terror. Five African countries (Burkina Faso, Mali, Somalia, Niger, and Nigeria) are among the most affected by terrorism in the world (Global Terrorism Index, 2022¹). The economic cost of terrorism for African countries has been estimated at 15.5 billion² in 2019. Thus, terrorism impacts public and private economic and social activities (Ndumbe *et al.*, 2005; Elnahass *et al.*, 2022; Blomberg *et al.*, 2004; Abadie *et al.*, 2003; Frey, 2004).

In Africa, more than anywhere else, border taxes remain a significant source of government revenues (Cantens *et al.*, 2017; Ghosh *et al.*, 2004). Customs, therefore, play a crucial role in the stability of the State during conflicts. The mission of customs administration is essential in controlling and managing border trade activities and tax collection. However, the combination of smugglers and terrorist groups that control trade routes and establish violence affects customs operations. The borders are regularly the battleground between government troops and terrorist groups. Closing customs checkpoints at borders and expanding illicit trade across borders (Cantens *et al.*, 2017) drastically constrain public revenue mobilization. For example, in Lake Chad, the jihadist group Boko Haram controls the trade route between Chad and Nigeria (Hoinathy, 2021). Insecurity in northern Mali hinders the presence of customs units at the borders. Thus, the failure of the State to manage borders allows terrorist groups to collect "taxes" to finance their activities and consequently drastically reduces the State's ability to mobilize the resources necessary to finance public goods and war.

African countries are exporters of gold (Grynberg *et al.*, 2020), often one of these countries' primary revenue sources. Gold is a precious mineral for extremist groups because it represents easy-to-sell war booty. In this context, the illicit trade in ores such as gold poses a significant challenge to the customs administration. Thus, the article empirically analyzes the impact of terrorism on customs fraud of gold in Africa.

While issues related to trade fraud have been the subject of much research since the 1960s, few studies have explicitly focused on the performance of customs administrations in a conflict context. Thus, many articles have aimed to measure fraud in international trade, including Bhagwati (1964) for Turkey, Carrere & Grigoriou (2015) for World Trade, Raballand *et al.* (2013) for Cameroon, Cariolle *et al.* (2019) for Gabon. Some of these articles and others have aimed to study the determinants of these frauds. For example, the relationship between tax rate and fraud has been investigated extensively, including by Bhagwati (1964) for Turkey, by Fisman & Wei (2004) for bilateral trade between China and Hong Kong, in India by Kumar *et al.*

1 "Measuring the impact of Terrorism," Global Terrorism Index Report, 2022.

2 "Measuring the Economic Impact of Violent Extremism in Africa," 2019 report, United Nations Development Program.

(2008), in Africa by Worku *et al.* (2016), in Mozambique by Van Dunem and Arndt (2009), in Kenya and Tanzania by Levin and Widell (2014) and in Tunisia by Rijkers *et al.* (2015).

Issues directly related to customs performance have emerged more recently. Issues of corruption and management of administrations are addressed by Chalfin (2008), Cantens (2012, 2013), Chalandard *et al.* (2020), Raballand (2009), among others. Cantens & Raballand (2017; 2021), forerunners of the literature on customs performance in conflict zones, focus on the governance of trade in border regions during a conflict or post-conflict situation, exploring the practices and strategies of customs agents operating at insecure borders.

Our paper's first contribution is to establish an empirical link between terrorism and customs fraud based on an exhaustive African database. Second, the article contributes to the debate on the role of war in state-building. Indeed, authors such as Tilly (1985) argue that war allows the State to be built, notably through reforms implemented to collect more taxes to finance the war. Conversely, some authors (Taylor *et al.*, 2008; Reno, 1998; Thies *et al.*, 2004) attest that war deconstructs already fragile states. Our paper thus tests Tilly's theory by focusing on the link between terrorism and the performance of customs administrations in the fight against fraud. Lastly, the paper is scope because it is the first study to focus on 50 African countries' gold trade mirror. No study about customs fraud has focused on an extractive mineral like gold, yet a crucial source of tax revenues in most African countries.

Gold customs fraud is estimated from an analysis of gold mirror data for 50 African countries between 2000 and 2019, using COMTRADE data. The mirror data analysis was used in 1964 for the first time by Bhagwati (1964) to estimate Customs fraud in Turkey. It has since been used in many academic works and recently by the customs of several African countries for customs risk management (Cantens, 2015; Geourjon *et al.*, 2022). The variable of interest, " the number of deaths during the incidence of terrorism," is taken from the Global Terrorism Database (GTD). We use many estimators to evaluate the effect of terrorism on gold customs fraud in Africa. Our results suggest that terrorism enhances gold customs fraud in Africa. To attest to the robustness of the baseline results, we perform our empirical strategy by using a Local impulsion method (Jordà, 2005) and the two-step system Generalized Methods Moments (Blundell & Blond, 1998). Our findings show that terrorism impulse a positive reaction to customs fraud.

The remainder of the article is structured as follows. Section 2 presents a short literature review. Section 3 describes our measure of gold customs fraud and the empirical approach. Section 4 discusses the results and includes several robustness checks. Concluding remarks and policy recommendations are given in Section 5.

2. Trade in Precious Ores and Terrorist Financing: A Brief Review of the Literature

The United Nations have recognized the relationship between illicit trade and terrorism through UN Security Council Resolution 2195. The financing of jihadist groups' activities relies on controlling illicit trade at the borders (Shelley, 2020). The insecurity generated by terrorism impacts trade routes through attacks by terrorist groups and the destruction of road infrastructures. In the Sahel, extremist group activities have destabilized the border and customs administration (Munshi, 2021). The weakness of the State then encouraged the development of corruption and illicit trade (Meriman, 2000; Shelley, 2020; Reno, 1998; Mansfield, 1995). So, war facilitates smuggling activities in Africa (Titeca *et al.*, 2011). Smuggling then allows trade to continue in the presence of terrorist groups in agreement with them.

Customs performance depend on the level of illicit trade crossing the border tolerated by national and local authorities (Titeca *et al.*, 2014). Consequently, conflict and smuggling activities reduce the performance of the customs administration (Van *et al.*, 2018). Indeed, controlling the flow of goods and taxing them at the borders during a war is very complex as rebel groups establish tax competition on the trade route (Cantens, 2019). For instance, terrorist groups in Somalia levied taxes on the coasts at around \$150,000 per year per ship (Bueger, 2013). Similarly, in the Democratic Republic of Congo, the fall of President Mobutu in 1998 led to the loss of administrative control over certain territories. Diamond smuggling activities across the Ugandan border increased by \$1.1 million in 1998 (Raeymaekers, 2010).

Fragile borders facilitate illicit commodity trafficking (Golub, 2015; Ndumbe, 2005). In the context of the war economy, gold is an essential ore for financing terrorist activities (Gold, 2004). Titeca *et al.* (2011) document that the smuggling of cigarettes and commodities such as gold finances the war economy in the eastern part of the Democratic Republic of Congo (DRC). In this way, according to a UN panel on the DRC: 'As long as an ounce of refined gold is worth more than \$400 while a used Kalashnikov gun can be bought for less than \$40, the incentives to gain control of Congo's resources through violent means will be overpowering'. According to the OECD (2018), 20 tons of gold were reportedly smuggled from Burkina Faso to Togo in 2018 (Solazzo, 2018). Also, according to United Arab Emirates (UAE) customs data, 15.1 billion of smuggled gold from Africa is estimated to have entered the country in 2018 (Levis *et al.*, 2019). Gold is produced in many African countries and is easy to transport discreetly, therefore financing terrorism in many countries.

In the following section, we implement an empirical strategy to estimate the impact of terrorism on customs fraud in Africa for gold.

3. Methodology and data

We first present our measurement variables of gold customs fraud and terrorism indicators. Secondly, we show the empirical strategy of our general model. Lastly, we explore some data used in the study.

3.1. Measures of gold customs fraud (“Customs fraud”) and terrorism (“Deaths”)

Illicit trade is traceable by the balance of payment data, such as trade statistics (Bhagwati, 1964; Buehn *et al.*, 2012). Our measure of gold custom fraud is the missing export of gold measured in monetary value. Cantens (2015) defines mirror analysis (or mirror data) as "the comparison between the import (or export) data of a country X and the data for imports to (or exports from) country X by one or more countries." Since Bhagwati (1964), many authors have used mirror analysis to detect customs fraud that may be a consequence of smugglers' actions. Mirror data analysis has even received renewed attention since some developing country administrations use it in their risk analysis and management systems (Geourjon *et al.*, 2022). We measure gold custom fraud as the value of missing gold export.

Missing export is thus captured by the difference between mirror exports (partner imports) and export values as reported by the country. Because imports are measured CIF and exports FOB, we correct mirror exports by 15% to have an indicator based on FOB-FOB comparison, as is common in the literature (Chalandard, 2015). Building on Chalandard and al. (2019) or Ndikumana and Boyce (2018), the missing gold export is the following:

$$DX_{t^k} = \sum_{i=1}^J (M_{ji} - \beta X_{ij}) \quad (1)$$

DX represents the missing gold export in a given year by country. A positive DX is a sign of missing gold export, such as customs fraud. The data is taken from the COMTRADE database, and we use disaggregated Harmonized System 6 (HS) gold commodities. By construction, this measure underestimates fraud in the gold trade because it is based on imports declared.

We measure terrorism activities by the number of civil deaths during terrorist acts from the Global Terrorism Database (GTD). It captures the number of deaths caused by terrorism incidents by year for each sample country.

3.2. Empirical strategy

To estimate the effects of terrorism on Gold customs fraud for a panel of 50 African countries from 2000 to 2019, we use the specification as Chalandard (2017):

$$\ln(CUSTOMFRAUD_{it}) = \beta \ln(DEATHS_{it}) + \theta Z_{it} + \alpha_i + \varepsilon_{it} \quad (2)$$

Where “Customs fraud” is the measure of the missing gold export (as defined in eq.1); “Deaths” measures civil deaths during terrorism incidence, it is our interest variable; β measures the coefficient of the interest variable. It measures the change in missing gold exports associated with a unit increase of terrorism incidence; Z_{it} the matrix of control variables, α_i the individual country fixed effects, and ε_{it} the error term.

Discrepancies in trade data may be due to factors other than fraud, such as valuation differences (CIF-FOB), exchange rate conversion problems, unintentional misclassification, and others (Geourjon *et al.*, 2022). However, like Chalandard (2017), we reasonably assume that export misreporting is unrelated to the error term. The estimator is then unbiased.

In order to avoid different biases, we use four control variables: Trade openness, mineral rents, GDP per capita, and Corruption (see annex 2). Regarding the control variable, we preferred to use "trade" rather than "tariff," usually used to explain fraud. Indeed, most of the articles focus on import fraud, which results in particular from the application of high tariffs. In contrast, most countries no longer apply export tariffs. It cannot, therefore, be a determinant of export fraud.

Trade openness has been the subject of numerous works about industrialization, growth, and corruption. Indeed, trade openness is closely linked to trade liberalization, which has reduced trade barriers (Cagé, 2019). On one side, trade may have less incentive for customs fraud. Michael (2012) attested that trade facilitation help to reduce corruption at customs agencies. Moreover, trade liberalization has also been accompanied in many countries by strengthening control procedures using the most recent technologies (data mining, scanners) to process exponential trade flows (Cagé, 2014). However, on another side, trade openness would promote customs fraud. Trade liberalization may have reduced customs officers' efforts in their control activities (Mikesell, 2013). The relationship between trade openness and customs performance is indeed ambiguous. Adamson (2006) attested that trade enhances the onset of war, based on historical examples, of the relationship between trade and war. However, liberals' theories assume that war decrease trade through the economic recession (Barbieri *et al.*, 1999).

Low GDP per capita can lead to corruption among officials and increased illicit trade (Islam *et al.*, 2019). Economic performance, therefore, impacts the efficiency of the customs administration (De Wulf *et al.*, 2005). Furthermore, Collier (1999) and Sevastianova (2009) detailed the relationship between GDP per capita and conflict. Many authors have studied the relationship between natural resources and informal trade. Blanton *et*

al. (2021) found that natural resource wealth increases informal trade in developing countries. Mantz *et al.* (2018) showed that illicit ore trade is associated with resource abundance in DR Congo. There is also a strong relationship between mineral rents and conflict. Berman *et al.* (2017), among others, found that rising ore prices increase local conflicts in Africa. Fisman and Wei (2004) have shown that discrepancies in trade data were very strongly correlated with corruption. The relationship between corruption and conflict has been documented by Arezki *et al.* (2013) and Le Billon (2008).

In the framework of our empirical strategy, we will first use both the least square estimator (OLS) and the fixed effects estimator (FE). We use the Hausman test to specify between fixed and random effects. In addition, we use another estimator, such as a two-stage least squares estimator, to control for possible reverse causality between divergences in the gold trade and the incidence of terrorism. Indeed, violence generated by terrorism involves the porosity of borders and the weakness of customs administration (Cantens, 2019). As mentioned in the previous section, states can close borders in countries affected by conflict and implement a solid military presence at borders. This reaction of states against insecurity impacts the functioning of customs administration. Also, the fall of state power caused by jihadist groups raises smuggling activities across the border (Cantens *et al.*, 2017). However, reversely, customs performance can explain terrorist activities. The low performance of customs administration and border control can enhance smuggling activities. Indeed, the high level of corruption of civil servants at the border can facilitate the sharing of informal trade. Cantens (2019) supports that smugglers are allied with terrorist groups to destabilize borders in the Sahel area.

Consequently, we use a two-stage least squares estimator to resolve the endogeneity. We use the annual temperature as an instrument. The annual temperature is relevant because the climate impacts African social conflict and anti-governance violence (Hendrix *et al.*, 2012). Burke *et al.* (2009) have shown that warming raises the risk of war in Africa. Also, most literature has argued that climate disturbance leads to social violence and conflict in Africa (Brown *et al.*, 2007; Raleigh *et al.*, 2012; Hsiang *et al.*, 2014). On the subject of the relationship between terrorism and climate change, Regan *et al.* (2022) have identified that precipitation increases with acts of terrorism by using binomial regression. About African countries, Price *et al.* (2016) have attested to a positive relationship between temperature and Islamism terrorism in Nigeria. We implement a fixed effect test to estimate the relationship between terrorism and temperature.

We present the first-stage equation of the two stages least squares as follow:

$$DEATHS_{it} = \beta TEMPERATURE_{it} + \theta Z_{it} + \alpha_1 + \varepsilon_{it} \quad (3)$$

In equation (3), DEATHS is the number of civil deaths during terrorism incidences by country and year. Temperature_{it} is the annual temperature per year for each country of the sample. Z_{it} is the set of control variables. We additive years and countries with the fixed effect.

Some authors, such as Mattoo *et al.* (2009) and Huang *et al.* (2011), have shown a relationship between climate change and trade. To resolve this bias, we added trade as a control variable. Similarly, Alagidede *et al.* (2016), Carleton *et al.* (2016), and Ireland (2010) have theorized the relationship between climate change policy implications and economic development in Africa. We used GDP per capita as a control variable to control this indirect relationship. In addition, we added some control variables, such as mining rents and corruption, to avoid omission bias.

Results in the annex support the relevance of the instrument. It shows a solid significant and positive relationship between deaths caused by terrorism and annual temperature. Our results are consistent with those of Berke *et al.* (2009).

4. Data descriptive overview and results

4.1. Data descriptive overview

Table 1 shows the descriptive statistics of the variables included in the analysis. The investigation of the table shows 1000 observations both for gold export missing and the deaths during terrorist attacks. The degree of deaths during terrorist incidences is limited on a scale between 0 and 771—zero denoting no death and 771 identifying the maximum of deaths during terrorist attacks from 2000 to 2019. We note, on average, a value of 117,9 deaths in the larger countries in the sample. The gold export missing is measured in logarithm on a scale from 3.526 to 23.133, with a mean of 15.361.

Table 1. Summary Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
Log Export missing	1000	15.361	3.66	3.526	23.133
Number of deaths	1000	117.944	454.211	0	771
Corruption	1000	-0.644	.616	-1.905	1.23
Trade	1000	72.047	38.763	1.219	347.997
Political Stability	1000	-.589	.909	-3.315	1.282
Temperature	1000	24.12	4.861	-.687	29.555
GDP per Capita	1000	2345.218	2930.592	258.629	16989.96
Rent	1000	1.055	2.674	0	24.834

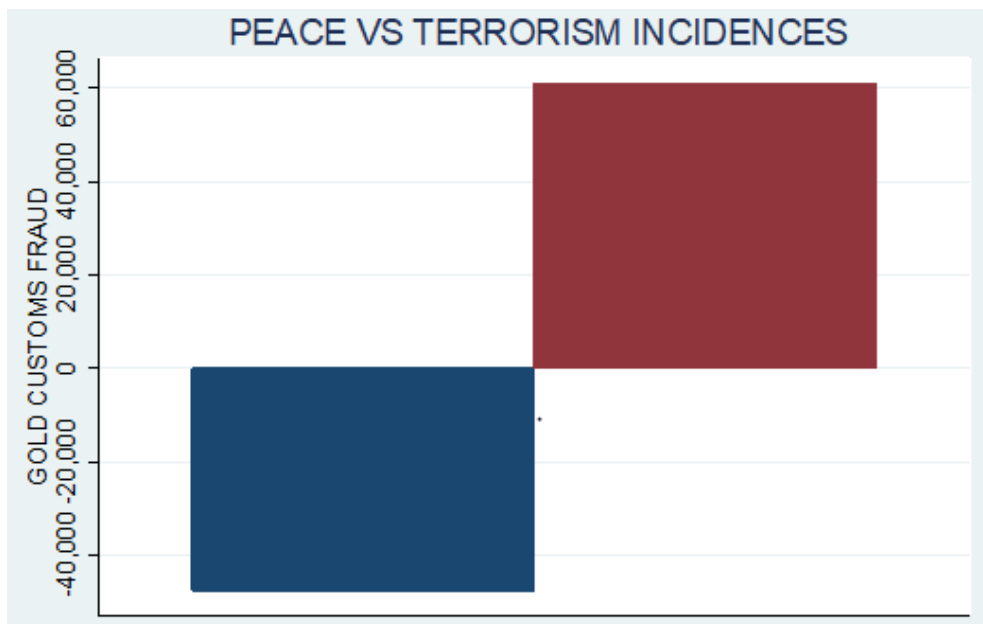
Table 2 present the matrix of correlations. We present a primary relationship between deaths of terrorism and gold customs fraud. We attest to a positive correlation between deaths and gold customs fraud (Export missing). The correlation supports our intuition: terrorism is an enhancer for gold customs fraud.

Table 2. Matrix of correlations

Variables	Export missing	Deaths	Trade	Rent	GDP per capita	Corruption
Exporting missing	1.000*					
Deaths	0.050*	1.000				
Trade	0.021*	-0.115*	1.000			
Rent	-0.052*	-0.058*	0.217*	1.000		
GDP per capita	-0.007*	0.020*	0.243*	-0.115*	1.000	
Corruption	0,076*	-0.212*	0.191*	-0.004*	0.230*	1.000

Figure 1 presents a stylized fact, notably the gold customs fraud in times of peace against the gold customs fraud according to exposure to terrorism. Data show that, on average, a negative missing gold export in times of peace. On the contrary, during terrorist acts, the gold export missing is positive. Smugglers promote trade mis-invoicing and illicit cross-border flows for many reasons: disguising capital flight, hiding commercial profits abroad, e.g., in tax havens, financing illicit activities, avoiding tariffs and taxes, introducing illicit products (Nitsch, 2011; UNECA, 2015; World Customs Organization, 2018).

Figure 1. Stylized facts, gold customs fraud in times of peace (Blue) vs. the gold customs fraud according to exposure to terrorism (Red)



The preliminary data show that terrorism promotes illicit cross-border flows. In the next section, we present empirical results.

4.2. Estimation results

Results reveal that terrorism incidences increase gold customs fraud. Indeed, the coefficient is both significant and positive in OLS and FE specifications (Table 3). We found that raising 1 percent in deaths during terrorism increases gold customs fraud to 0,45 (OLS) and 0,57 (Fixed effect) percent.

Table 3. Linear fixed-effects model

	(1) OLS	(2) Fixed effect
Deaths (Ln)	0.4536*** (0.1489)	0.5780*** (0.1552)
Corruption	-0.3628 (0.6287)	2.7025 (1.9866)
GDP per capita	0.0003** (0.0001)	0.0016*** (0.0006)
Rent	0.1164 (0.0999)	0.2341 (0.2323)
Trade	-0.0166 (0.0110)	-0.0768*** (0.0211)
Constant	14.2262*** (0.9528)	17.9977*** (2.4291)
Nbs. of observations	1000	1000
R ²	0.2	0.5
Country fixed effect	YES	YES
Hausman test	FE	FE
Year fixed effect	YES	YES

Notes: robust standard errors are in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

As mentioned above, we use the two least squares estimator with annual temperature as an instrument. The first level of the two least squares shows that the temperature coefficient is statistically significant (see annex 1). These findings mean that countries with high annual temperatures are more likely to be victims of terrorism. Considering the second stage of the two least squares results, we found that raising 1 percent of deaths caused by terrorism increases gold customs fraud to 0,52 percent (Table 4).

**Table 4. Effect of terrorism on gold customs fraud
(Instrumental variables for panel-data models)**

Deaths (Ln)	0.5200*** (0.1654)
Corruption	-0.0361 (1.0741)
GDP per capita	0.0004** (0.0001)
Rent	0.1493* (0.0812)
Trade	-0.0351** (0.0155)
Constant	15.5484*** (1.0443)
Nbs. Of observations	1000
R ²	0.16
Country fixed effect	YES
Hausman test	FE
Year fixed effect	YES

Notes: robust standard errors are in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1

We show that terror raises illicit trade flows, particularly illicit gold trade at African borders. Our empirical results support the theoretical assumption of Cantens *et al.* (2019) that terrorism activities decrease customs efficiencies at borders and thus weaken state consolidation. Moreover, our results show that conflict decreases public administration performance by raising customs fraud. In consequence, findings challenge Tilly's theory promoting the positive impact of conflict in tax mobilization of the State.

Regarding control variables, we found a statistically positive relationship between GDP per capita and customs fraud. Elgin *et al.* (2014) attested that a higher GDP per capita is associated with a larger informal size where the institutional quality is low. Aziz *et al.* (2014) and Buehn *et al.* (2012) also found a positive relationship between smuggling and GDP per capita. Mining rent enhances gold customs fraud. Also, we show that trade decreases gold customs fraud. Our results are similar to Michael (2012).

5. Robustness check

In a framework of robustness test, we first use an alternative estimator such as the GMM estimator (Blundell & Blond, 1998). Secondly, we implement a local projection estimation for Jordà (2005).

5.1. Generalized Methods Moments (Blundell & Blond, 1998)

The two-step system Generalized Methods Moments helps deal with the endogeneity issue between terrorism and customs fraud because it benefits large cross-sections. Moreover, this estimator helps to address both endogeneity issues and omitted variables.

Moreover, we employ an alternative measure of terrorism activities. Indeed, we use the terrorism measures perceptions of the political instability from the World Bank Governance Indicator. The indicators' units rise with the political stability/ absence of instability due to terrorism.

We present the equation with the two-step system Generalized Methods Moments as follows:

$$\ln CUSTOMFRAUD_{it} = \alpha + \eta_i + \theta \ln CUSTOMFRAUD_{it-1} + \beta STABILITY_{it} + \sigma' X_{it} + \varepsilon_{it} \quad (4)$$

Where *CUSTOMFRAUD*(export missing trade) represents the dependent variables. *STABILITY*_{it} represents political stability with perceptions of terrorism incidences of the country *i* at time *t*. The term η_i is the country-specific effect, ε_{it} is the unobserved random error term. The vector *X* represents the set of control variables, and σ' is the associated vector of parameters.

Our results (Table 5) show that the absence of political instability due to terrorism decreases African customs fraud. Raising 1% of political stability decreases missing gold export to 1,79. The findings confirm our preliminary results.

Table 5. Effect of terrorism on gold customs fraud (GMM for panel-data models)

Customs fraud (LAG)	0.7401*** (0.0908)
Stability	-1.7947** (0.8145)
GDP per Capita	-0.0002 (0.0006)
Trade	0.0053 (0.0150)
Rent	1.2419*** (0.3371)
Constant	2.1118 (1.4823)
<i>N</i>	900
AR1	.0046
AR2	.8032
Hansen Test	.5969

Notes: robust standard errors are in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.2. Local projection method (Jordà, 2005)

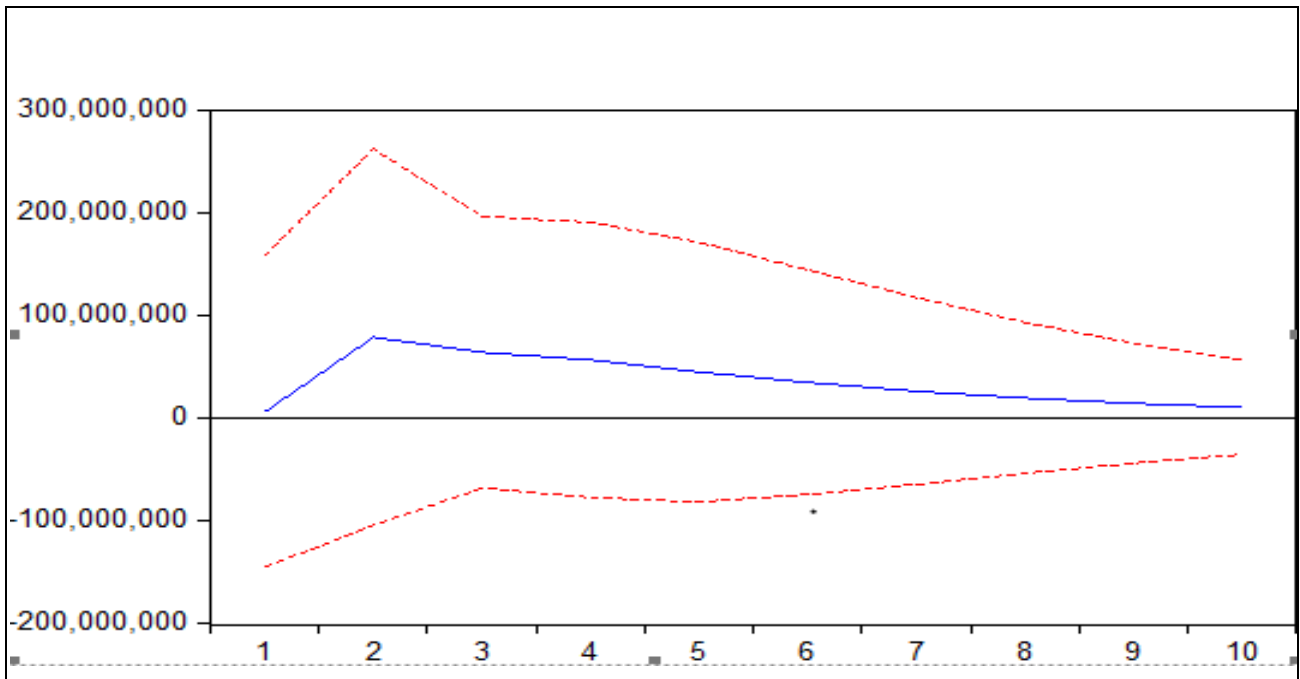
We implement another robustness test by using an alternative estimator. Using the local projection method, we estimate the average medium-term effect of terrorism on gold customs fraud. We use this approach because it is both flexible to estimate the response of macroeconomic variables and allows several robustness checks in a different definition of the response variable, such as the gold customs fraud in this study. We consider terrorism as an external shock to customs fraud.

We are interested in the response of customs fraud to terrorism. The estimation is a series of regressions for each horizon (h). The local projection method of Jordà (2005) implies the following equation:

$$CUSTOMFRAUD_{t+h} - CUSTOMFRAUD_t = c + \beta h DEATHS_t + (L)Controls_{t-1} + \epsilon_t \quad (5)$$

Our findings (Figure 2) show that one terrorism shock initially increases gold customs fraud between the 1 and 2,5 periods. The positive response to gold customs fraud sharply declines until the 2,5th period. The response gradually declines but stays positive. In sum, the shock of terrorism positively impacts gold customs fraud. These results confirm the baseline results about the relationship between terrorism and customs fraud.

Figure 2. The impulse response of gold customs fraud to terrorism



Notes: the x-axis measures units of customs fraud, the y-axis measures time

6. Conclusion and policy implications

This paper explores the effect of terrorism on gold customs fraud in Africa from 2000 to 2019. We measure terrorism by the number of deaths caused by terrorism. Missing gold exports are used to measure gold customs fraud. We use ordinary least squares and two-stage least squares as estimators in our empirical strategies to estimate the impact of terrorism on gold customs fraud.

We find that terrorism increases gold customs fraud. Indeed, insecurity caused by extremist groups promotes illicit trade through porous borders. Our results show that customs administration is strongly affected by terrorist activities in Africa. Using the local impulse strategy (Jordà, 2005), we also show that the impulse response of gold customs fraud to terrorism is positive.

Our results suggest that states affected by terrorism must pay more attention to the trafficking of gold, as this is a valued mineral for terrorist groups. The response to conflict with terrorist groups cannot be solely military. Work on fragile borders (Cantens *et al.*, 2017) shows that it is essential for security interventions to pay attention to the border economy. Thus, it is necessary to consider security measures in terms of their impact on this local economy. The presence of the civil State in crisis zones, mainly through customs and tax administrations, makes it possible to restore people's confidence in the State, provided that government policies meet social justice needs and not just the need to collect taxes (Cantens, 2019). To realize this arduous objective, the State must necessarily get the various state services to work together, particularly the army, the police, and the customs. The institutionalization of this cooperation remains a real challenge for these states. Breaking down the barriers between all state services, civilian and military, will help to restore some confidence in the State and will help to build a more effective strategy to combat illicit trade.

Regarding customs administrations, developing countries have been implementing modernization reforms for about 15 years. The use of data is at the core of this modernization. The first stage of this modernization is about the use of data with the objective of better targeting commercial fraud. Customs has mobilized internal and external data for several years to improve its risk analysis and management system. In the second stage, the fragile border context should also allow customs administrations to move to the next level in the use of data, and in particular, the use of geolocation data and satellite data, already used by the armies of many countries. Cooperation with the armed forces must allow the acquisition of tools and skills to analyze them. In this way, customs could combine "office" data with "frontier" data, enabling it to carry out all of its border missions: collecting duties and taxes, protecting the local/border economy of these countries, and thus cutting off the sources of financing for terrorist groups.

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**Annex 1. Effects of temperature on terrorism with fixed effect
(First stage of two squares estimator)**

	FE
Temperature	0.5666* (0.3208)
GDP per capita	-0.0001 (0.0005)
Rent	0.0162 (0.0606)
Corruption	-0.0603 (0.4496)
Constant	-10.5545 (8.1612)
<i>Nbs. Of observation</i>	1000
Countries fixed effect	YES
Hausman test	FE
Year fixed effect	YES

Notes: robust standard errors are in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Annex 2. Variables

Customs Fraud	Missing export is thus captured by the difference between mirror exports (partner imports) and export values as reported by the country.	COMTRADE Database, United Nations
Trade openness (%GDP)	Sum of exports and imports of goods and services measured as a share of gross domestic product	World Development Indicators, World Bank
Mineral rents	Difference between the value of production for a stock of minerals at world prices and their total costs of production	World Development Indicators, World Bank
GDP per capita	Gross Domestic Product per Capita	World Development Indicators, World Bank
Corruption	Transparency, accountability, and corruption in the public sector rating (1=low to 6=high)	World Development Indicators, World Bank
Terrorism Activities	number of civil deaths during terrorist acts	Global Terrorism Database
Political stability/ Absence of instability due to terrorism	Terrorism measures perceptions of the likelihood of political instability	World Wide Governance Indicator, World Bank