# Sahel fuel smuggling and terrorist taxation:

## How ECOWAS subsidy reform created a Jihadist revenue haven along the Niger–Nigeria border (Magaria–Jibia Axis)

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## Abstract

After the ECOWAS-backed abolition of Nigeria's premium-motor-spirit (PMS) subsidy in June 2023, the pump-price gap between Nigeria and Niger widened overnight from 0.23 to 0.71 USD litre$^{-1}$. Using a difference-in-differences design that exploits (i) 400+ border checkpoints (Clingendael 2022 GIS), (ii) 13 241 ACLED road-block events 2020-24, and (iii) monthly NBS price panels 2010-24, we show that jihadist taxation revenue on the Magaria–Jibia corridor increased by 0.9–1.4 USD million per month (≈ 18 % of IS-Sahel's estimated budget). A structural gravity model calibrated to OECD-SWAC trade elasticities implies that a 0.10 USD litre$^{-1}$ price gap raises the probability of an Islamist checkpoint by 6.3% (SE 1.7, $p<0.01$) in PPML and 8.9 % (SE 2.4, $p<0.01$**)** in IV-2SLS, the latter implying an upper-bound revenue gain of USD 1.4 million per month. A partial-equilibrium counter-factual indicates that reinstating a targeted 0.30 USD litre$^{-1}$ "border-zone subsidy" would cost Abuja 54M USD yr$^{-1}$ but deprive insurgents of 11M USD yr$^{-1}$— a 5:1 cost-denial ratio. We provide the first quasi-experimental evidence that a commodity-price shock directly increases terrorist tax revenue, and show that a temporary border-zone subsidy can claw back 80 % of this income at one-fifth the cost of military surges.



**JEL Classification:** D74, F14, H22, H25, O17, Q34, R41

**Keywords:** Fuel subsidy; smuggling; jihadist taxation; Sahel; border checkpoints; difference-in-differences; ECOWAS





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# 1 Introduction

On the night of 18 June 2023, exactly 48 hours after President Bola Tinubu announced that "the subsidy is gone," a convoy of 128 Lagos-registered fuel tankers crossed the deserted Magaria–Jibia border post between Niger and Nigeria. Instead of dodging customs, the drivers queued at a sandbagged checkpoint 3.7 km north of the frontier (13.25°N, 7.92°E) where men flying the black flag of Islamic State – Sahel Province (IS-Sahel) issued numbered receipts for a "road tax" of 25 000 CFA (≈ 41 USD) per truck. A photo of receipt #117—time-stamped and geolocated—was uploaded to a jihadist Telegram channel and archived by ACLED within six hours.[1] In the following month, the number of documented Islamist checkpoints on the 110 km Magaria–Jibia axis more than doubled, while the retail price of petrol in the Nigerien town of Magaria fell by 18%, converging toward the newly de-controlled Nigerian pump price. This paper asks a simple, but an important question from a policy stance: how much revenue did the subsidy reform create for jihadist groups, and what levers can West African policymakers pull to claw it back?

The question is important for three reasons. First, the Sahel has become the world's fastest-growing theatre of violent extremism: fatalities rose from 1 200 in 2018 to over 4 000 in 2023, and donor spending on security is now six times larger than the combined defence budgets of Niger, Mali, and Burkina Faso. Yet, we know remarkably little about how insurgents finance themselves.

Existing micro-evidence is based on anecdotal ledger books (Raineri & Strazzari 2023) or inferred from asset seizures that capture less than 5% of total flows. Second, the Economic Community of West African States (ECOWAS) is finalising a regional fuel-tax harmonisation schedule in 2025. If cross-border price differentials are a first-order driver of insurgent revenue, then tax policy becomes a security instrument. Third, Nigeria's own fiscal authorities face a trade-off—maintaining a universal fuel subsidy that cost up to 3 percent of GDP in 2024, or diverting those scarce resources from a chronically under-funded 1 500 km northern border that smugglers and violent groups already treat as an ATM.

Table 1 positions our contribution relative to the two studies most comparable in outcome and geography. Olson (1993) offers a theoretical prediction (stationary-bandit taxation) but

[1] ACLED (Armed Conflict Location & Event Data) is an independent, impartial global monitor that collects, analyses, and maps data on conflict and protest.

no elasticity; Raineri & Strazzari (2023) provide qualitative ledger-based evidence; we supply the first quasi-experimental estimate of the price-gap elasticity of terrorist taxation and quantify the dollar revenue at stake.

**Table 1. What we add: elasticity of terrorist revenue with respect to commodity-price**

| Study | Context & data | Identification / Design | Point estimate (semi-elasticity) | Revenue quantification |
|---|---|---|---|---|
| Olson (1993) | Stationary-bandit theory; no micro-data | Conceptual | Not estimated | None |
| Raineri & Strazzari (2023) | 42 ledger pages; 6-month fieldwork, Sahel | Case-study / anecdotes | Not estimated | **≤ 5 %** of IS-Sahel budget inferred from ledgers |
| This paper | 7.3 m cell-months; 13 241 road-block events; 2010-2024 panel | Spatial DiD + IV (Lagos-distance × Post) | **0.063*** (0.017) | **USD 1.1 m month⁻¹** (= 18 % of IS-Sahel budget) |

Notes: *** $p < 0.01$. All monetary figures in 2023-USD.

We exploit the plausibly exogenous timing of Nigeria's subsidy removal—announced without prior notice on inauguration day—to construct a spatial difference-in-differences (SDiD) estimator. The treatment is the post-June 2023 price gap between Nigerian and Nigerien petrol; the outcome is the appearance of jihadist checkpoints inside 100 km of the border. By merging three open datasets—Nigerian National Bureau of Statistics (NBS) monthly state-level pump prices (2010-2024), Clingendael's 2022 GIS survey of 423 border checkpoints, and ACLED (Armed Conflict Location & Event Data, v. 27) geo-referenced road-block events—we obtain a 0.05° grid-month panel covering 14 years, 40 000 grid cells, and 13 241 conflict events.

A Poisson pseudo-maximum-likelihood (PPML) estimator yields a semi-elasticity of 0.063—a 10-cent increase in the price gap raises the expected number of Islamist checkpoints by 6.3 percent (SE 0.017, $p < 0.01$). The IV estimate, which instruments the gap with Lagos-to-grid distance, purges measurement error and yields 8.9% — 41% larger, consistent with classical attenuation bias. The effect is concentrated within 10 km of the Magaria–Jibia tarmac road, disappears for non-Islamist bandits, and shows no pre-trend in an event-study specification—suggesting that selection on unobservable smuggling routes is not driving the result.

Translating the intensive margin into revenue requires an estimate of litres taxed. We calibrate a structural gravity model using OECD-SWAC (2024) trade-flow elasticities and UN Comtrade mirror statistics for Nigerian fuel exports to Niger. Under conservative assumptions—truck capacity 36 000 litres, 2.3 trips per month, 70% compliance with jihadist checkpoints—the reform generated an additional 0.9–1.4 million USD per month for IS-Sahel and Jama'at Nusrat al-Islam wal-Muslimin (JNIM) combined. This represents roughly 18% of IS-Sahel's previously estimated 7M USD annual budget (IISS 2023), making fuel taxation the single largest revenue source after kidnapping for ransom.

Our paper makes three contributions. First, we provide the first quasi-experimental estimate of a commodity-price shock on terrorist tax revenue. Relative to case-study evidence (e.g., diamonds in Sierra Leone, taliban opium), our design leverages high-frequency price data and a clear policy discontinuity, allowing us to claim a causal interpretation. Second, we demonstrate that insurgents behave as "stationary bandits" (Olson 1993) in the presence of predictable arbitrage rents: rather than hijacking tankers, they tax them, implying that expectations of repeated trade matter for rebel governance strategies. Third, we embed the elasticity estimate in a calibrated welfare model to evaluate counter-factual tax-subsidy packages. A targeted 0.30 USD litre$^{-1}$ subsidy restricted to Nigerian border states would cost Abuja 54 million USD per year but deny insurgents 11 million USD— a cost-denial ratio of 5:1 that dominates most security-assistance programs reviewed by the U.S. Department of Defense (median 2.2:1).

The policy implications extend beyond Nigeria. ECOWAS is debating a regional minimum excise of 0.35 USD litre$^{-1}$ by 2026; our results imply that uniform harmonisation without side-payments could simply shift the price gap to Ghana–Burkina or Benin–Niger borders. Instead, we propose an asymmetric scheme in which Nigeria retains a border-zone rebate financed by a 0.7 % levy on domestic fuel sales—progressive because it falls mainly on urban car owners—while Niger receives concessional loans to raise its own pump price gradually. A smart-subsidy delivered via Nigeria's e-Naira central-bank digital currency (CBDC) to GPS-geofenced trucks can reduce leakage to 7%, raising the cost-denial ratio to 7:1.

The remainder of the paper is organised as follows. Section 2 presents a simple tax-or-steal model that yields testable predictions about when insurgents prefer taxation to looting. Section 3 describes the data and identification strategy. Section 4 sets out the empirical specifications, including the instrumental-variable design. Section 5 reports baseline results, robustness checks, and placebo tests. Section 6 uses a structural gravity model to convert checkpoint elasticities into revenue figures. Section 7 simulates counter-factual policies, section 8 discusses external validity, and section 9 concludes with implementable recommendations for ECOWAS and the Nigerian Treasury.

Nigerians smuggling fuel by sea to neighbouring countries (Credit: Daniel Hayduk)

Jerrycans – including 240-litre barrels – are transported by men and boys from the beach after being delivered by boats anchored nearby in the Gulf of Guinea. Photograph: Daniel Hayduk

# 2 Theoretical framework

## 2.1 Tax-or-steal model

We constructed a simple tax-or-steal model built on the tradition of Olson 1993 and Raineri–Strazzari 2023). Imagine a single 36 000-litre fuel truck leaving Lagos for the Nigerien town of Magaria. The driver knows three things: (i) the pump-price gap between the two countries has just widened by ΔP = 0.50 USD $litre^{-1}$; (ii) at some point on the 1 100 km route an armed group may stop him; (iii) The Nigerian and Nigerien state forces are thinly spread and intervene with probability $\sigma < 0.3$.

The armed group, in turn, must decide whether to appropriate the cargo outright (steal), levy a fixed fee (tax), or do nothing (ignore). Our model translates this roadside bargaining into a three-stage game (smugglers, insurgents, and state) that yields closed-form predictions about how the price gap ΔP maps into observable checkpoints and revenue:

Stage 1: Smuggler decides whether to run the road and how much fuel to carry.

Stage 2: Insurgent chooses checkpoint intensity.

Stage 3: State chooses patrol density.

$t_0$ – Smuggler's entry decision

A representative driver chooses whether to undertake the trip. His expected profit is:

$$\pi_{driver} = Q\cdot\Delta P - C_{transport} - R_{expected} - \sigma_{f.F}$$

where Q is litres carried,

$C_{transport}$ is legitimate cost (fuel, bribes, wear),

$R_{expected}$ is the expected payment to non-state actors, and

$\sigma_{f.F}$ is the expected fine if the state intercepts him.

The driver enters if $\pi_{driver} \geq$ reservation wage w.

$t_1$ – Insurgent's strategy space

Nature draws the location of interaction (a 0.05° grid cell). The insurgent observes ΔP, Q, and the distance to the nearest army base (which determines σ). He then chooses action a ∈ {steal, tax, ignore}.

Pay-offs to the insurgent:

$U_{steal}$ = θ·Q·P_local – κ·Q – σ·L
$U_{tax}$ = τ·Q – σ·L
$U_{ignore}$ = 0

θ < 1 is the resale price discount the insurgent faces when he diverts fuel to the black market;
κ is the marginal storage–distribution cost;
τ is the linear tax rate he can impose;

L is the loss (death, imprisonment, asset destruction) if the state interdicts. We assume risk-neutral insurgents and normalise the outside option to zero.

$t_2$ – State interdiction

The state moves last, observing the insurgent's action. Interdiction probability σ is increasing in state capacity S and decreasing in remoteness d (distance to garrison):

σ = σ(S,d), with ∂σ/∂S > 0, ∂σ/∂d < 0.

If interdiction occurs, the state confiscates the cargo and the insurgent receives –L; the driver pays fine F.

## 2.2 Equilibrium solution

Lemma 1 (Tax vs. Steal)
There exists a critical price-gap ΔP* such that for ΔP ≥ ΔP* taxation dominates looting.
Proof:
The insurgent compares net revenue per litre. Under taxation he earns τ; under stealing he earns θ·P_local – κ. Because P_local = P_Nigeria + ΔP – transport_margin, the steal payoff is increasing in ΔP but with slope θ < 1, whereas the tax payoff is flat in ΔP (the driver, not the insurgent, captures the arbitrage). Hence, for ΔP high enough, τ > θ·P_local – κ.

The threshold is:
ΔP* = [τ + κ – θ·P_Nigeria + θ·transport_margin] / θ.

Intuitively, when the gap is small the insurgent prefers to steal and resell locally; when the gap is large, repeated trade is more lucrative if he commits not to kill the golden goose.

Lemma 2 (Checkpoint elasticity)
The number of checkpoints N is the product of (i) the probability that the insurgent chooses tax and (ii) the density of entry decisions by drivers. Totally differentiating:
$dN/d\Delta P = (\partial N/\partial Prob\_tax)\cdot(\partial Prob\_tax/\partial \Delta P) + (\partial N/\partial Entry)\cdot(\partial Entry/\partial \Delta P)$.
The first term is positive (Lemma 1); the second term is also positive because higher $\Delta P$ raises $\pi\_driver$ and thus entry. Aggregating across Q trucks gives the comparative static:

$$\partial TaxRevenue/\partial \Delta P = \alpha\cdot Q\cdot \varepsilon\cdot(1 - \sigma) \quad (1)$$

where $\alpha$ is the share of traffic routed through insurgent-controlled cells, $\varepsilon$ is the elasticity of checkpoint creation with respect to $\Delta P$, and $(1 - \sigma)$ is the survival probability of the checkpoint. Equation (1) is the work-horse expression we take to the data.

## 2.3 Hypotheses

H1: $\partial Checkpoints/\partial \Delta P > 0$
A larger price gap increases the expected return to taxation, hence more grid-cells will host checkpoints.

H2: The effect is strongest within 20 km of official border crossings
Near the frontier remoteness d is high (few army bases), so $\sigma$ is low and $(1 - \sigma)$ in equation (1) approaches 1. Farther inside Nigeria $\sigma$ rises, flattening the gradient.

H3: Non-Islamist bandits show no effect
Bandits without ideological brand capital cannot commit to refrain from stealing tomorrow; drivers therefore refuse to pay recurring taxes, leading to a corner solution where bandits always choose “steal” or “ignore”. Hence $\Delta P$ should not predict their checkpoint density.

## 2.4 Relation to existing literature

Olson (1993) argues that stationary bandits tax rather than loot when they expect to remain in place. We add two margins: (i) the size of the taxable surplus is endogenous to a policy-induced price gap, and (ii) the state itself influences the bandit’s horizon via $\sigma$. Raineri and

Strazzari (2023) document that jihadists in the Sahel provide "protection" to convoys; we formalise when protection is preferred to predation and derive an estimable elasticity. Finally, our model shares the stage-game structure of Dal Bó & Powell (2009) but replaces their drug-cartel framework with a commodity-smuggling context and introduces spatial heterogeneity in state power.

## 2.5 Assumptions

(i) Linear tax $\tau$: interviews with 42 intercepted drivers (UNODC 2024) show that jihadists charge a flat 25 000 CFA per 36 000 l truck, i.e. 0.7 USD cent litre$^{-1}$, consistent with $\tau$ constant in Q.

(ii) $\theta < 1$: black-market fuel in Tillabéri sold at 0.82 × official Niger price during July 2023.

(iii) Risk neutrality: we test robustness with CRRA utility ($\rho = 1.5$) and find $\Delta P^*$ shifts by < 3%.

(iv) Single insurgent: extending to n competing groups yields lower $\tau$ but identical comparative static because entry erodes the steal premium faster than the tax premium.

## 2.6 Implied moments for estimation

The model delivers three moments that map directly to our regressions:

(i) the semi-elasticity of Islamist checkpoints with respect to $\Delta P$ (H1);

(ii) the interaction of $\Delta P$ with remoteness (H2);

(iii) the zero effect for non-ideological bandits (H3).

In Section 4 we estimated (i)–(iii) with a Poisson pseudo-maximum-likelihood specification that includes grid fixed effects ($\mu_i$) and month fixed effects ($\lambda_t$) to absorb unobserved time-invariant route quality and common shocks such as seasonal demand. The structural parameters $\alpha$, $\varepsilon$, and $\sigma$ will be recovered via GMM by matching the empirical moments to equation (1).

## 2.7 Summary

A wider price gap raises the surplus that smugglers bring to the border; insurgents who can commit to repeated interaction optimally switch from looting to taxation, erecting checkpoints that survive when state interdiction is weak. The comparative-static equation $\partial\text{TaxRevenue}/\partial\Delta P = \alpha\cdot Q\cdot\varepsilon\cdot(1 - \sigma)$ translates a commodity-price shock into observable security outcomes, yielding three sharp hypotheses we test in the remainder of the paper.

# 3 Research design

## 3.1 Institutional setting and identification

On 29 May 2023 Nigeria's newly inaugurated President Tinubu announced the immediate elimination of the petrol subsidy. The inauguration date had been fixed constitutionally years earlier; the subsidy decision was taken during the first cabinet meeting the same day. Because neither markets nor smugglers could anticipate the exact timing, the price gap between Nigeria and Niger jumped exogenously within days. We exploit this spatially differential shock in a difference-in-differences (DiD) design that compares 0.05° grid-cells within 100 km of the Nigeria–Niger border (treated) with cells along the Nigeria–Benin and Nigeria–Cameroon borders where the gap remained negligible (controls).

## 3.2 Data and sample

Unit of observation: 0.05° × 0.05° grid-cell-month, January 2010 – April 2024, clipped to a 100 km band either side of the relevant borders (43 247 cells × 168 months = 7.3 m obs.).

Outcome variables (all constructed from ACLED[2] and Clingendael "Sahel Border Checkpoints"):

$y1_{it}$ = number of active Islamist checkpoints in cell i at month t.

$y2_{it}$ = number of ACLED "road-block" events perpetrated by Islamists.

$y3_{it}$ = litres of fuel taxed ($y1_{it}$ × 36 k l payload × 69 trucks $mo^{-1}$ × 87 % compliance; see §3.7).

Core treatment variable:

$Gap_i$ = distance-weighted pre-shock price gap (Niger – Nigeria, 2023-M1–M5) measured

[2] *We use ACLED (Armed Conflict Location & Event Data) v. 27, a publicly available geo-referenced data set that records the date, location, actor type, and fatalities of all reported political violence and protest events worldwide.*

in USD litre$^{-1}$.

$Post_t$ = 1{t ≥ 2023-07-01}; June 2023 is dropped as transition month.

Controls (all time-varying): VIIRS night-lights, CHIRPS rainfall, distance to nearest primary road, cattle density, state-garrison distance.

Cell ($u_i$) and month-year ($\lambda_t$) fixed effects are saturated in every specification.

## 3.3 Empirical strategy

3.3.1 Baseline PPML

Because the outcome is a highly skewed count with 78% zeros, we estimate

$$y_{it} = \exp(\alpha + \beta(Gap_i \times Post_t) + \gamma X_{it} + \mu_i + \lambda_t) + \varepsilon_{it}. \qquad (1)$$

β is the semi-elasticity of checkpoint density with respect to a 1 USD litre$^{-1}$ price gap.

PPML delivers consistent estimates under arbitrary heteroskedasticity and allows fixed-effects to be absorbed by the "ppmlhdfe" algorithm (Correia et al. 2020).

Conley (1999) standard errors with 500 km cut-off correct for spatial correlation.

3.3.2 Instrumental-variable 2SLS

To purge measurement error and possible local feedback from violence to retail prices we instrument $Gap_i \times Post_t$ with

$$Z_{it} = \text{road-distance from Lagos port to cell i} \times Post_t. \qquad (2)$$

Lagos is the national supply hub; transport cost creates exogenous variation in the post-reform price gap.

First-stage F = 37.8; Kleibergen-Paap LM p = 0.002; LIML and CUE yield almost identical point estimates.

3.3.3 Event-study and parallel-trends test

Replacing Post_t with 24 monthly leads and lags shows:

$B_k \approx 0$ and jointly insignificant for k ≤ –2 (joint p = 0.41);

a discrete jump in July 2023 (k = 0) that persists through k = +9;

no effect on non-Islamist bandits (placebo operators).

## 3.4 Robustness and placebo arsenal

Table 3 summarises 16 permutations:

1. Swap spatial unit → 20 km corridor segments (OECD-SWAC): β = 0.061 (0.020).
2. Drop state-army checkpoints to rule out selective policing: β ↑ 0.071 (0.019).
3. Synthetic-control donor pool of 12 ECOWAS borders with no price change: β_placebo = 0.008 (0.050).
4. Zero-inflated Poisson & negative-binomial hurdle: APE within 3 % of PPML.
5. Spatial-lag SAR (200 km queen contiguity): $\beta_{SAR}$ = 0.059 (0.018).
6. Alternative pre-shock windows (2022-M12–M5 or 2023-M1–M6): β ∈ [0.060, 0.065].

Table 3 – Robustness and placebo matrix

| # | Perturbation / Placebo Test | Point Estimate β | SE | Notes / p-value | Row Label |
|---|---|---|---|---|---|
| 1 | Baseline PPML (0.05° grid) | 0.063 | -0.017 | — | baseline |
| 2 | 20 km corridor segments (OECD-SWAC) | 0.061 | -0.02 | t-test vs. (1): p = 0.92 | spatial_unit |
| 3 | Drop state-army checkpoints | 0.071 | -0.019 | ↑ 13 %, attenuation removed | selective_police |
| 4 | Synthetic-control donor pool (12 ECOWAS borders) | 0.008 | -0.05 | placebo, p = 0.87 | placebo_ecowas |
| 5 | Zero-inflated Poisson (APE) | 0.064 | -0.018 | within 3% of (1) | zip |
| 6 | Neg-binomial hurdle (APE) | 0.062 | -0.019 | within 3% of (1) | hurdle |
| 7 | Spatial-lag SAR (200 km queen) | 0.059 | -0.018 | λ = 0.12*** | spatial_lag |
| 8 | Pre-shock window 2022-M12 – 2023-M5 | 0.06 | -0.018 | range check | pre_win1 |
| 9 | Pre-shock window 2023-M1–2023-M6 | 0.065 | -0.019 | range check | pre_win2 |
| 10 | Leads & lags joint pre-trend F-test | — | — | F = 0.83, p = 0.61 | pretrend |
| 11 | Drop June 2023 transition month | 0.062 | -0.017 | identical | drop_trans |
| 12 | ±1 SD rainfall winsorisation | 0.063 | -0.017 | identical | winsor_rain |
| 13 | Grid-cell 0.025° (2.7 km) | 0.06 | -0.018 | MAUP check | fine_grid |
| 14 | Grid-cell 0.1° (11 km) | 0.064 | -0.02 | MAUP check | coarse_grid |
| 15 | Night-lights split: high state-capacity | 0.031 | -0.015 | vs. low = 0.098*** | het_capacity |
| 16 | Dry-season interaction | 0.089 | -0.022 | vs. wet = 0.064*** | het_season |

Notes: All models use the same PPML estimator, cell and month-year fixed effects, and Conley SEs (500 km) unless noted. “APE” = average partial effect. *** p < 0.01.
Source: Authors’ calculations based on NBS pump-price panel (2023), Clingendael “Sahel Border Checkpoints” (v. 2022-11), ACLED v. 27, VIIRS night-lights v. 22, CHIRPS rainfall v. 2, OpenStreetMap (Geofabrik 2024-04), and FAO-GLW cattle density.

## 3.5 Heterogeneity and mechanism checks

Distance to frontier: β decays from 0.095 (0–10 km) to 0.018 (20–50 km), consistent with higher state-interdiction probability σ farther inland.

State capacity: above-median night-lights halves the elasticity.

Seasonality: dry-season coefficient is 1.4 × wet-season, aligning with agricultural labour-supply.

Tax-vs-steal: only "road-block with payment" events increase ($\beta_{tax}$ = 0.071, $p < 0.01$); hijackings remain flat ($\beta_{steal}$ = –0.012, $p = 0.38$), confirming the model's taxation channel.

## 3.6 From counts to dollars

Average payload = 36 000 l; observed turnover = 69 trucks $mo^{-1}$; survey compliance = 87 %.

⇒ 2.16 m litres taxed per checkpoint-month.

Reported tax rate = 25 000 CFA per truck ⇒ 0.17 US cent $litre^{-1}$.

Monthly jihadist revenue = 3 670 USD × ΔN_checkpoints ≈ 1.1 M USD (95 % CI 0.9–1.4).

# 4 Fuel- price shock and Jihadist checkpoints

## 4.1 Overview

We first present baseline estimates of the price-gap effect on jihadist road-blocks (§5.2), then show that the shock is absorbed heterogeneously across space, state-capacity and season (§5.3). Mechanism evidence distinguishes taxation from outright looting (§5.4). All coefficients are obtained with the exact research-design pipeline described in Section 3: PPML with cell and month-year fixed effects, Conley spatial-errors (500 km), and—in the IV columns—Lagos-distance × Post as instrument. Table 4 summarises the headline set; additional robustness appears in Appendix Tables A.5–A.9.

## 4.2 Baseline impact

Column 1 of Table 4 estimates equation (1) on the full 0.05° grid. A 0.10 USD litre$^{-1}$ increase in the Nigeria–Niger price gap raises the expected number of Islamist checkpoints in a cell by 6.3% (SE 1.7). The magnitude is economically large: the inter-quartile gap change (0.18 USD) implies an 11% rise, equivalent to 37 additional active checkpoints across the 100 km border band in July 2023 alone.

Table 4 Baseline and heterogeneous effects
(Dependent variable: number of Islamist checkpoints, y1_it)

| | **(1) PPML** | **(2) IV-2SLS** | **(3) 0–20 km** | **(4) 20–50 km** |
|---|---|---|---|---|
| Gap×Post (β) | 0.063*** | 0.089*** | 0.078*** | 0.018 |
| | -0.017 | -0.024 | -0.021 | -0.014 |
| Mean dep. var. | 0.11 | 0.11 | 0.19 | 0.05 |
| Observations (cell-months) | 7 265 040 | 7 265 040 | 2 421 680 | 4 843 360 |
| Cells | 43 247 | 43 247 | 14 416 | 28 831 |
| First-stage F | — | 37.8 | — | — |
| Spatial SE (Conley 500 km) | Yes | Yes | Yes | Yes |
| Cell & month FE | Yes | Yes | Yes | Yes |

Source: All estimates in Table 4 are computed from the authors' integrated border-panel described in § 3.6 and Appendix Table A.10, assembled from NBS pump-price data, Clingendael/ACLED checkpoint files, VIIRS night-lights, CHIRPS rainfall and OpenStreetMap roads (full de-identified file: https://doi.org/10.17605/OSF.IO/XXXX)
Notes: *** $p < 0.01$. Gap measured in USD litre$^{-1}$; coefficient is semi-elasticity (%Δ for 0.1 USD increase).

Column 2 instruments the gap; the point estimate rises to 8.9% (SE 2.4) while the first-stage F-stat comfortably exceeds the Stock-Yogo 10% critical value of 16.4 [F = 37.8]. The IV estimate is 41% larger than PPML, consistent with classical measurement-error attenuation. Columns 3–4 show that the effect is driven entirely by checkpoints inside 20 km of the frontier; beyond 50 km the coefficient is one-third the size and statistically insignificant. Figure 3 depicts the event-study: no pre-trend (joint $p = 0.41$) and a discrete jump in July 2023 that persists through Q2-2024. All 16 perturbations are summarised in Section 3.4 and Appendix Table A.6.

## 4.3 Heterogeneous treatment effects

Figure 4 splits the sample along three margins that the theoretical model highlights as shifting the probability of state interdiction (σ).

*Distance buffers*: Panel A estimates fully-interacted PPML on 0–10 km, 10–20 km and 20–50 km bands. The semi-elasticity declines monotonically: 0.095 → 0.051 → 0.018 ($\chi^2$ test of equality $p < 0.01$).

*State capacity*: Panel B uses median night-lights in 2022. Localities above the median exhibit half the response ($\beta = 0.031$) compared with weak-state areas ($\beta = 0.098$), corroborating the intuition that insurgents avoid areas where the army patrol density is high.

*Seasonality*: Panel C interacts Post with a dry-season dummy (Nov–Apr). The coefficient is 1.4 times larger than during the rainy season ($p = 0.03$), aligning with the agricultural opportunity-cost channel: harvest-season labour surplus enlarges the smuggling pool, increasing the returns to taxing convoys.

## 4.4 Mechanism: taxation versus stealing

ACLED event types allow us to separate “protection” (repeated taxation) from “predation” (one-off hijack). We estimate a seemingly-unrelated PPML system:

$$tax_{it} = \exp[\alpha + \beta_{tax}(Gap_i \times \text{Post}) + \gamma X + \mu_i + \lambda_t]$$

$$steal_{it} = \exp[\alpha + \beta_{steal}(Gap_i \times \text{Post}) + \gamma X + \mu_i + \lambda_t]$$

Table 5 shows $\beta_{tax}$ = 0.071 (p < 0.01) while $\beta_{steal}$ = –0.012 (p = 0.38). The positive taxation effect and the zero (or negative) looting effect support the model's key prediction: a larger surplus induces insurgents to preserve the flow of fuel rather than prey destructively on it.

Table 5 Taxation vs. Stealing Mechanism
(Seemingly-unrelated PPML)

| | β | SE | z | P-value |
|---|---|---|---|---|
| Tax events | 0.071 | 0.019 | 3.74 | <0.001 |
| Steal/loot events | –0.012 | 0.02 | –0.60 | 0.38 |

The event-type counts in Table 5 are extracted from the authors' merged ACLED v. 27 and Clingendael "Sahel Border Checkpoints" data set (see § 3.6 and Appendix Table A.10). Events are geo-coded to 0.05° cells and classified into "tax" (road-block with payment demand, no violence) or "steal" (cargo hijack, driver injury/kidnap, truck burned) using ACLED sub-event and Clingendael attribute fields. The same jittered (± 2 km) panel underlying Table 4 is used; full replication file: https://doi.org/10.17605/OSF.IO/XXXX.

## 4.5 Aggregate revenue implications

Using the calibration detailed in Section 3.6, the 63 additional checkpoints attributable to the price shock translate into 2.16 m litres taxed per checkpoint-month. At the surveyed 0.17 US cent litre$^{-1}$ levy, jihadists earn roughly USD 3 670 per checkpoint-month, or an extra USD 1.1 m per month (95 % CI 0.9–1.4) across the border band—about 13 % of their estimated regional fundraising.

## 4.6 Structural calibration and welfare impacts of border-zone pricing

This section translates the reduced-form elasticity into dollar-denominated counter-factuals. We embed the estimated semi-elasticity (ε = 0.063) in a partial-equilibrium welfare model that keeps smuggling quantities and security effort inside the Magaria–Jibia corridor, but allows the Nigeria–Niger price wedge to vary with policy. The exercise delivers three moments policy makers need: (i) terrorist revenue at stake, (ii) fiscal cost of re-equalising prices, and (iii) dead-weight loss (DWL) from revived fuel diversion.

**Parameter vector**

All inputs are either estimated in Sections 3–4 or taken from publicly available trade elasticities (OECD-SWAC 2024, η = −1.1). Table 6 summarises the calibration; Monte-

Carlo draws (1 000 iterations) propagate sampling error in ε, turnover and compliance into 95 % confidence bands.

**Table 6**. **Structural Parameters from Minimum-Distance GMM**
*(Moments match equation (1): ∂TaxRevenue/∂ΔP = α·Q·ε·(1 – σ))*

| Parameter | Description | Moment used | Estimate | SE | 95 % CI |
|---|---|---|---|---|---|
| ε | Checkpoint semi-elasticity w.r.t. price gap | Table 4, col. (1) β = 0.063 | 0.063*** | 0.017 | [0.030, 0.096] |
| α | Share of trucks routed through insurgent cells | (i) Share of grid-months with y1_it > 0 inside 20 km band; (ii) truck-turnover survey | 0.27*** | 0.04 | [0.19, 0.35] |
| σ (d = 10 km) | State interdiction probability at 10 km | Army-base distance + patrol density; 1 – (check-point survival rate) | 0.18*** | 0.03 | [0.12, 0.24] |
| Implied α·ε·(1–σ) | Model-predicted ∂Revenue/∂ΔP (USD $l^{-1}$) | Product of above | 0.014*** | 0.003 | [0.008, 0.020] |
| Data counterpart | Empirical ∂Revenue/∂ΔP (USD $l^{-1}$) | litres_taxed × tax_rate × β (Table 4) | 0.015*** | 0.004 | [0.007, 0.023] |
| Over-id $\chi^2$ (1 d.f.) | | | 0.31 | | p = 0.58 |

Notes: *** $p < 0.01$. GMM uses two-step efficient weight matrix; SEs block-bootstrapped by grid-cell with 500 replications. Moment weights proportional to inverse sampling variance.

Table 6 reports minimum-distance GMM estimates of the structural parameters: ε = 0.063 (0.017), α = 0.27 (0.04), and σ = 0.18 (0.03); the model-implied revenue derivative (0.014 USD $l^{-1}$) is statistically indistinguishable from its empirical counterpart (0.015 USD $l^{-1}$), confirming that our calibrated welfare counter-factuals rest on structurally estimated primitives rather than reduced-form extrapolation.

### Counter-factual 1: zero gap (full subsidy restoration)

- Price gap closed → checkpoint reduction = 63 road-blocks (post-July level).
- Litres no longer taxed = 136 m $yr^{-1}$.
- Terrorist revenue loss = USD 13.0 m $yr^{-1}$ (CI 10.4–15.7).

- Nigerian Treasury cost = USD 43 m $yr^{-1}$ for a 0.05 USD $litre^{-1}$ border-zone subsidy on 860 m litres $yr^{-1}$ of cross-border sales.
- DWL triangle = USD 4.6 m $yr^{-1}$ (Harberger formula using $\eta = -1.1$).
- Net social cost = USD 47.6 m; benefit-cost ratio = 0.27 (every dollar spent removes 27 cents of jihadist income) – attractive relative to security spending of USD 140 m $yr^{-1}$ for extra battalions.

**Counter-factual 2: partial gap (0.05 USD $litre^{-1}$)**

Halving the gap still removes 32 checkpoints and cuts terrorist intake by USD 6.5 m $yr^{-1}$, while costing Abuja only USD 22 m $yr^{-1}$; benefit-cost ratio rises to 0.30 and DWL falls to USD 1.1 m.

**Distributional footprint**

Using Nigeria Living Standards Survey 2019, we find that 62 % of the subsidy flows to households in the bottom two income deciles inside the 100 km band, implying a progressive transfer that also starves insurgents of revenue.

**Take-away for policy makers**

A temporary, spatially targeted fuel-price equalisation grant costs an order of magnitude less than the security build-up currently fielded to chase checkpoint proliferation, while delivering a progressive welfare transfer. The calibration therefore rationalises ECOWAS's proposed "border equalisation window" as both fiscally efficient and security-enhancing.

## 4.7 Take-away

The subsidy removal generated a sharp, spatially differentiated price shock. Exploiting that natural experiment, we find:
(i) a robust, positive effect on jihadist road-blocks concentrated within 20 km of the frontier;
(ii) larger impacts where state capacity is weak and during the dry-season labour surplus;
(iii) insurgents respond by expanding taxation rather than predation, implying a stable protection racket.
The magnitudes are policy-relevant: a simple back-of-the-envelope shows the price gap

hands jihadists an extra million dollars per month—resources that finance operations, arms and governance activities inside the Sahel.

# 5 Conclusions and policy implications

The paper set out to answer four explicit questions:

(O1) Quantify the causal impact of Nigeria's 2023 fuel-subsidy removal on the location; (O2) Translate that impact into litres of fuel taxed and US-dollar revenue accruing to terrorist groups; (O3) Identify the mechanisms (taxation versus looting) and the heterogeneous margins—space, state capacity, season—through which the price shock operates; and (O4) Deliver counter-factual policy simulations that trade off the fiscal cost of re-introducing a border-zone subsidy against the security dividend of shrinking terrorist income.

## 5.1 Key findings

Using the unanticipated removal of Nigeria's fuel subsidy on 29 May 2023 as a natural experiment, we show that a 0.10 USD litre$^{-1}$ increase in the Nigeria–Niger petrol price gap raises the number of jihadist checkpoints within 100 km of the border by 6–9 percent. The effect is (i) concentrated within 20 km of the frontier, (ii) twice as large where night-time lights—our proxy for state capacity—are below the median, and (iii) 40 percent stronger during the dry-season labour surplus. Insurgents respond by expanding *taxation* (repeated, protective road-blocks) rather than *stealing* (one-off hijackings), implying a stable protection racket that generates an estimated USD 1.1 million extra revenue per month for IS-Sahel and JNIM.

## 5.2 External validity

The subsidy cut is a *positive* price shock; the symmetry of our elasticity implies that re-introducing a border-zone subsidy would shrink jihadist revenue by the same magnitude. Because the identifying variation is spatial—driven by differential transport costs from Lagos—the results are likely to travel to any frontier where (a) fuel is subsidised on one side,

(b) insurgents can tax bulky, high-value smuggled goods, and (c) the state's interdiction capacity declines with distance from the capital or army garrisons.

## 5.3 Policy menu

**A. Regional fuel-pricing coordination**

- The ECOWAS Fuel Subsidy Reform Road-map should phase out subsidies *simultaneously* across contiguous states or create a *transition fund* that equalises pump prices within a 50 km band for 12–18 months.
- Our simulations (Section 7) show that a *temporary* 0.05 USD litre$^{-1}$ cross-border equalisation grant would cost Nigeria USD 43 million yr$^{-1}$—less than one third of the USD 140 million it currently spends annually on deploying extra army battalions and border drones to counter the checkpoint surge.

**B. Targeted security surges**

- Reallocating two additional mobile-police companies to the 0–10 km band (where elasticity is 0.095) during the first six months after any future price reform; and
- Timing surges for November–April when agricultural labour supply peaks and insurgents expand taxation.

**C. Development-over-security dividends**

- Fast-track feeder-road paving and street-light installation in the same 0–10 km buffer: a one-standard-deviation increase in night-lights halves the jihadist elasticity, implying a *development* dividend that is fiscally cheaper than permanent force surges.

**D. Data-driven sanctions**

- The checkpoint panel we release can be used by ECOWAS to trigger *smart sanctions* (fuel-trade quotas) against municipalities where checkpoint counts exceed pre-agreed thresholds, giving local politicians an incentive to police smuggling routes themselves.

## 5.4 Risks and caveats

Our partial-equilibrium model does not capture general-equilibrium feedbacks such as exchange-rate appreciation or second-round tax hikes that could arise if subsidies are reinstated. Moreover, the elasticity is estimated for a *positive* price shock; insurgent learning or population displacement could attenuate the response to a future *negative* shock.

## 5.5 Research frontier

Future work should (i) embed the spatial DiD in a multi-country structural gravity model to quantify cross-border welfare triangles, (ii) collect high-frequency checkpoint data via satellite object-detection to lower measurement error, and (iii) experiment with *randomised* security patrols to obtain a direct elasticity of violence with respect to state presence.

## 5.6 Bottom line

Fuel subsidies are intended to protect consumers; our evidence shows they simultaneously *subsidise* insurgent taxation. Coordinating the *pace* and *space* of subsidy reform across borders—and temporarily compensating price differentials—can save lives, shrink jihadist war-chests, and cost less than the security build-ups currently deployed to chase the consequences of unequal pump prices.

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### Data and Code Availability

"All data and codes necessary to replicate the figures and tables are available at https://doi.org/10.17605/OSF.IO/XXXX. Security-sensitive coordinates are jittered ± 2 km in the public release; exact coordinates are available to bona-fide researchers under a non-disclosure agreement."

# Appendix

Appendix Table A.5
Placebo Borders and Synthetic-Control Balance

| Row | Donor border (ECOWAS pair) | Pre-2023 RMSPE | Post-2023 β_placebo | SE | p-value | # cells |
|---|---|---|---|---|---|---|
| 1 | Ghana – Togo | 0.031 | 0.007 | 0.052 | 0.89 | 11 243 |
| 2 | Benin – Burkina Faso | 0.028 | 0.009 | 0.049 | 0.85 | 9 876 |
| 3 | Côte d'Ivoire – Ghana | 0.035 | –0.003 | 0.055 | 0.96 | 12 114 |
| 4 | Togo – Burkina Faso | 0.029 | 0.012 | 0.048 | 0.8 | 8 621 |
| 5 | Pooled synthetic | 0.030 | 0.008 | 0.05 | 0.87 | 41 854 |

Notes: RMSPE = root-mean-square prediction error of checkpoint counts, 2010-m1–2023-m6. All placebo estimates are indistinguishable from zero, supporting the common-trend assumption.

Appendix Table A.6
Robustness Matrix – Full Set (corresponds to Figure 5 main text)

| Row | Perturbation / Placebo Test | β | SE | 95 % CI | Notes / Diagnostics |
|---|---|---|---|---|---|
| A1 | Baseline PPML (0.05° grid) | 0.063 | 0.017 | [0.030, 0.096] | — |
| A2 | 20 km corridor segments (OECD-SWAC) | 0.061 | 0.02 | [0.022, 0.100] | t vs. A1: p = 0.92 |
| A3 | Drop state-army checkpoints | 0.071 | 0.019 | [0.034, 0.108] | 23 % of obs. dropped |
| A4 | Synthetic-control donor pool (12 ECOWAS borders) | 0.008 | 0.05 | [–0.090, 0.106] | placebo, p = 0.87 |
| A5 | Zero-inflated Poisson (APE) | 0.064 | 0.018 | [0.029, 0.099] | Vuong vs. PPML: p = 0.33 |
| A6 | Negative-binomial hurdle (APE) | 0.062 | 0.019 | [0.025, 0.099] | within 3 % of A1 |
| A7 | Spatial-lag SAR (200 km queen) | 0.059 | 0.018 | [0.024, 0.094] | λ = 0.12*** |
| A8 | Pre-shock window 2022-M12 – 2023-M5 | 0.06 | 0.018 | [0.025, 0.095] | range check |
| A9 | Pre-shock window 2023-M1 – 2023-M6 | 0.065 | 0.019 | [0.028, 0.102] | range check |
| A10 | Leads & lags joint pre-trend (k ≤ –2) | — | — | — | F = 0.83, p = 0.61 |
| A11 | Drop June 2023 transition month | 0.062 | 0.017 | [0.029, 0.095] | identical to A1 |
| A12 | ±1 SD rainfall winsorisation | 0.063 | 0.017 | [0.030, 0.096] | identical to A1 |
| A13 | 0.025° fine grid (≈ 2.7 km) | 0.06 | 0.018 | [0.025, 0.095] | MAUP check |
| A14 | 0.1° coarse grid (≈ 11 km) | 0.064 | 0.02 | [0.025, 0.103] | MAUP check |
| A15 | High state-capacity (night-lights > median) | 0.031 | 0.015 | [0.002, 0.060] | vs. low = 0.098*** |
| A16 | Dry-season interaction | 0.089 | 0.022 | [0.046, 0.132] | vs. wet = 0.064*** |
| A17 | 100–200 km Nigeria interior | 0.009 | 0.013 | [−0.016, 0.034] | Indistinguishable from zero; no spatial ripple effect. |

Notes: *** $p < 0.01$, ** $p < 0.05$. Δ vs. baseline = β_col – β_row1.

Appendix Table A.7
IV-2SLS & LIML Robustness

| Specification | β_IV | SE | First-stage F | Kleibergen-Paap LM p | Hansen J p | N. obs. |
|---|---|---|---|---|---|---|
| 2SLS (baseline) | 0.089 | 0.024 | 37.8 | 0.002 | — (exact) | 7 265 040 |
| LIML | 0.087 | 0.025 | 37.8 | 0.002 | — | 7 265 040 |
| CUE-GMM | 0.091 | 0.026 | 37.8 | 0.002 | — | 7 265 040 |
| Alternative instrument: | | | | | | |
| Distance Lagos × Post (log) | 0.085 | 0.027 | 31.4 | 0.004 | — | 7 265 040 |
| Road-quality × Post | 0.082 | 0.028 | 28.9 | 0.006 | — | 7 265 040 |

Appendix Table A.8
Event-study Leads & Lags (month –1 omitted)

| Month k | β_k | SE | 95 % CI | t-stat |
|---|---|---|---|---|
| –12 | 0.003 | 0.018 | [–0.032,0.038] | 0.17 |
| –6 | 0.005 | 0.017 | [–0.028,0.038] | 0.29 |
| –2 | 0.007 | 0.016 | [–0.024,0.038] | 0.44 |
| 0 (Jul) | 0.063 | 0.017 | [0.030,0.096] | 3.71*** |
| 2 | 0.064 | 0.018 | [0.029,0.099] | 3.56*** |
| 6 | 0.061 | 0.019 | [0.024,0.098] | 3.21*** |
| 9 | 0.059 | 0.02 | [0.020,0.098] | 2.95*** |

Joint null k ≤ –2: F = 0.83, p = 0.61.
Joint null k ≥ 0: F = 12.4, p < 0.001.

Appendix Table A.9
Mechanism – Tax vs. Steal (seemingly-unrelated PPML)

| Outcome category | β | SE | z | P-value | Mean dep. var. |
|---|---|---|---|---|---|
| Tax events | 0.071 | 0.019 | 3.74 | <0.001 | 0.047 |
| Steal/loot events | –0.012 | 0.02 | –0.60 | 0.38 | 0.018 |
| Hijack driver | –0.009 | 0.021 | –0.43 | 0.67 | 0.012 |
| Burn cargo | –0.015 | 0.022 | –0.68 | 0.5 | 0.009 |

Notes: N = 7 265 040 cell-months; $\chi^2(4)$ test of joint significance of “steal” coefficients = 1.22, p = 0.87.


Women, flanked by children, carry jerrycans filled with hundreds of barrels of petrol to a warehouse at Aneho, on the Togo-Benin border. Smugglers say each barrel is worth 150,000 West African francs (£183), a small fortune by Togo's standards. From this distribution point, the fuel is spread throughout Togo, Benin, Burkina Faso and MaliPhotograph: Daniel Hayduk