

Fiscal Overkill? Confiscatory Mining Taxation and Local Economic Activity in Zambia

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Abstract

In January 2019, Zambia raised effective mining tax rates to 86–105% of profits—the most confiscatory mining tax regime among major copper-producing nations. Industry warned of economic collapse: \$2 billion in halted investment, mine closures, and 21,000 job losses. Using satellite nighttime light data from NASA’s VIIRS Black Marble (2012–2023) and a difference-in-differences design comparing 21 districts in Zambia’s mining provinces to 94 non-mining districts, I find no detectable effect on local economic activity. The standardized effect size is essentially zero (SDE = 0.005), and randomization inference confirms the null ($p = 0.975$). The confidence interval rules out effects larger than 0.04 standard deviations. These findings suggest that confiscatory resource taxation does not produce the rapid, visible local economic collapse predicted by industry stakeholders—at least as captured by nighttime luminosity.

JEL Codes: H25, Q32, O13, Q38

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1. Introduction

How much can governments tax natural resources before killing the goose that lays the golden eggs? This question sits at the heart of development policy in resource-rich nations, where copper, oil, and minerals generate the fiscal revenues that fund schools, roads, and hospitals—but only if firms keep extracting. Zambia’s January 2019 mining tax reform offers a uniquely sharp test: overnight, the combined effective tax burden on copper mining rose from approximately 61.5% to 86–105% of profits, making Zambia the least competitive of twelve major mining jurisdictions (Cassel and Manley, 2021). Industry reactions were immediate and dramatic—First Quantum Minerals suspended expansion plans, Glencore announced the closure of its Mopani operations, and the Chamber of Mines projected 21,000 job losses (International Monetary Fund, 2019).

The economic logic behind these warnings is straightforward. At effective tax rates exceeding 85%, mines operate below their shutdown threshold, triggering closures, layoffs, and reduced procurement from local suppliers (Tilton and Guzmán, 2016). In mining-dependent communities where copper firms anchor the local economy, these downstream multiplier effects should produce visible economic contraction—fewer lights, less commercial activity, reduced consumption. The question is whether this narrative, however intuitive, holds up in the data.

This paper estimates the causal effect of Zambia’s 2019 mining royalty reform on local economic activity, using satellite-measured nighttime light intensity as the outcome variable. I exploit the sharp, nationwide timing of the policy change (January 1, 2019) in a difference-in-differences framework, comparing nighttime lights in 11 mining-dependent districts in the Copperbelt and North-Western provinces to 104 non-mining districts across the rest of the country. The 2012–2023 panel from NASA’s VIIRS Black Marble provides seven years of pre-reform data for parallel trends assessment and five years of post-reform outcomes.

The main finding is a precise null. The estimated effect of the mining tax reform on district-level nighttime light intensity is indistinguishable from zero: 0.002 (SE = 0.008), using all 21 districts in mining provinces as the treated group. Randomization inference, which permutes treatment assignment across districts 1,000 times, yields a two-sided p -value of 0.975, confirming that the observed effect is entirely consistent with chance. The 95% confidence interval $[-0.015, +0.018]$ rules out effects larger than 4.3% of a standard deviation—economically meaningful effects would need to be very small to remain compatible with this estimate.

The null is robust across specifications. Narrowing the treatment to the 11 core mining districts, log-transforming the outcome, controlling for copper prices interacted with mining

status, restricting to 2019 only (before the partial September reversal), and dropping the Lusaka outlier all produce coefficients centered on zero. A placebo test using 2016 as a fake treatment date does detect a differential “effect,” consistent with some pre-existing noise in the mining-district trend, but the true treatment timing shows no break relative to this background variation.

These findings contribute to the literature on resource taxation and the resource curse. A large body of work examines how commodity price shocks affect local economies ([Allcott and Keniston, 2018](#); [Dube and Vargas, 2013](#); [Berman et al., 2017](#)), but rarely do governments push tax rates to explicitly confiscatory levels, creating a natural experiment in the Laffer curve’s declining region. The closest precursors are [Aragón and Rud \(2013\)](#), who estimate mine-level local spillovers from a Peruvian gold mine, and [Manley and Guimbert \(2017\)](#), who document Zambia’s dependence on copper revenues without quasi-experimental variation. The broader resource curse literature ([Sachs and Warner, 2001](#); [Venables, 2016](#); [Ross, 2015](#); [Caselli and Michaels, 2013](#)) debates whether resource extraction helps or hurts development but typically examines cross-country correlations or long-run trends rather than the immediate local response to discrete tax shocks.

Why might confiscatory taxation fail to produce visible local economic collapse? Three mechanisms merit consideration. First, the partial reversal in September 2019—when the government removed the non-deductibility provision under industry pressure—limited the effective exposure window to nine months, potentially too short for nightlights to register the full adjustment. Second, mining communities may possess greater economic resilience than a single-industry narrative suggests: informal commerce, agriculture, and government services provide alternative livelihoods that sustain consumption even as formal mining employment contracts ([Hodler and Raschky, 2014](#); [Michalopoulos and Papaioannou, 2014](#)). Third, nightlights may simply be too coarse a proxy: district-level luminosity aggregates urban centers and rural peripheries, potentially diluting mine-specific effects across large geographic areas ([Henderson et al., 2012](#)).

The paper proceeds as follows. Section 2 describes the institutional setting and the 2019 reform. Section 3 introduces the data. Section 4 presents the empirical strategy. Section 5 reports results, and Section 6 discusses implications.

2. Institutional Background

Zambia is the seventh-largest copper producer globally, and copper accounts for approximately 75% of export revenues ([World Bank, 2020](#)). Mining operations concentrate in two provinces: Copperbelt Province, home to legacy mines dating to the colonial era (Kitwe, Mufulira,

Chingola, Luanshya, Chililabombwe), and North-Western Province, where newer large-scale operations have developed since the 2000s (Solwezi’s Lumwana and Kansanshi mines, Kalumbila’s Sentinel mine).

The 2019 Reform. On October 26, 2018, Zambia’s Finance Minister announced sweeping changes to the mining fiscal regime as part of the 2019 national budget. Effective January 1, 2019, the reform contained four provisions: (i) mineral royalty rates increased from a 4–6% sliding scale to 5.5–10%, with a new top rate of 10% when the London Metal Exchange copper price exceeded \$7,500 per metric ton; (ii) mineral royalties became non-deductible from corporate income tax—the single most impactful change; (iii) a 5% import duty was imposed on copper-cobalt concentrates; and (iv) a 15% export duty was levied on precious metals.

The combined effect was dramatic. Prior to the reform, the total effective tax burden on copper mining was approximately 61.5% of profits. Afterward, industry analyses calculated effective rates of 86–105%, depending on grade and cost structure (Cassel and Manley, 2021). This made Zambia the least competitive of twelve major copper-producing nations, including the DRC, Peru, Chile, and Australia.

Industry Response. Reactions were swift. First Quantum Minerals, operator of the Kansanshi and Sentinel mines (Zambia’s two largest), suspended a \$1.35 billion expansion and announced a review of all Zambian investments. Glencore declared the closure of its Mopani Copper Mines underground operations, citing “unsustainable” tax burdens. The Zambia Chamber of Mines projected 21,000 direct and indirect job losses. Under sustained industry pressure, the government partially reversed the reform in September 2019, removing the non-deductibility provision while retaining the higher royalty rates.

Identifying Variation. The reform provides clean quasi-experimental variation for three reasons. First, the timing is sharp: all provisions took effect simultaneously on January 1, 2019, with no prior phase-in or pilot. Second, the reform was fiscally motivated—driven by Zambia’s rising sovereign debt burden—rather than targeted at specific mining communities. Third, the geographic concentration of mining activity creates a natural treatment-control structure: mining districts in the Copperbelt and North-Western provinces are treated, while agricultural and urban districts elsewhere serve as controls.

3. Data

Nighttime Lights. The primary outcome variable is annual mean nighttime light intensity from NASA’s VIIRS Black Marble product (VNP46A4), measured in nanowatts per square centimeter per steradian (Román et al., 2018). I use the AllAngle Composite Snow-Free band, which provides the most complete spatial coverage for tropical Africa. The data span 2012–2023, yielding seven pre-reform and five post-reform years. I download annual composites for four MODIS tiles covering Zambia (h20v09, h20v10, h21v09, h21v10), extract approximately 1.3 million pixel values falling within Zambian territory, and aggregate to district-level means using GADM Level 2 administrative boundaries.

District Boundaries. I use GADM version 4.1 Level 2 boundaries for Zambia, which delineate 115 districts across 10 provinces. Each district-year observation represents the mean, median, and 75th percentile of pixel-level nighttime light intensity within that district’s polygon.

Treatment Classification. I classify 11 districts as mining-dependent based on the presence of major active copper or cobalt mining operations: Kitwe, Ndola, Mufulira, Chingola, Luanshya, Kalulushi, and Chililabombwe in Copperbelt Province; and Solwezi, Kalumbila, and Kasempa in North-Western Province; plus Mpongwe (Copperbelt). A broader treatment definition includes all 21 districts in these two mining provinces.

Copper Prices. I obtain monthly London Metal Exchange copper prices from the Federal Reserve Bank of St. Louis (FRED series PCOPPUUSD), averaged to annual frequency as a control variable.

Summary Statistics. Table 1 presents pre-reform summary statistics. Mining districts have higher average nighttime light intensity (0.566 vs. 0.267 nW/cm²/sr) consistent with greater economic activity around mine sites, though both groups exhibit substantial variation.

4. Empirical Strategy

I estimate the effect of the mining tax reform using a two-way fixed effects difference-in-differences specification:

$$\text{sinh}(\text{NTL}_{it}) = \alpha_i + \gamma_t + \beta(\text{Mining}_i \times \text{Post}_t) + \varepsilon_{it} \quad (1)$$

Table 1: Summary Statistics: Pre-Reform Period (2012–2018)

	Mining Districts	Non-Mining Districts
<i>Panel A: District Characteristics</i>		
Number of districts	11	104
<i>Panel B: Nighttime Light Intensity (Pre-Reform)</i>		
Mean NTL (nW/cm ² /sr)	0.566	0.267
SD NTL	0.681	2.304
Mean asinh(NTL)	0.465	0.075
SD asinh(NTL)	0.490	0.393
<i>Panel C: Nighttime Light Intensity (Post-Reform)</i>		
Mean NTL (nW/cm ² /sr)	0.558	0.246
SD NTL	0.648	2.103
Observations (district-years)	1380	
Years	2012–2023	

Notes: Mining districts are those in Zambia’s Copperbelt and North-Western provinces with active copper/cobalt mining operations: Kitwe, Ndola, Mufulira, Chingola, Luanshya, Kalulushi, Chililabombwe, Mpongwe, Solwezi, Kalumbila, and Kasempa. NTL is the annual mean nighttime light intensity from NASA VIIRS Black Marble (VNP46A4) measured in nanowatts per square centimeter per steradian.

where NTL_{it} is mean nighttime light intensity in district i and year t , α_i are district fixed effects absorbing time-invariant differences, γ_t are year fixed effects absorbing common shocks, Mining_i is a binary indicator for mining districts, and Post_t equals one for 2019–2023. The coefficient β captures the differential change in nighttime lights in mining versus non-mining districts after the reform. I use the inverse hyperbolic sine transformation to handle the right-skewed distribution of nightlights while preserving zeros. Standard errors are clustered at the district level (Cameron et al., 2008).

Identification. The identifying assumption is that mining-province and non-mining-province districts would have followed parallel trends in nighttime light intensity absent the reform. I assess this with an event study that replaces the pooled post indicator with year-specific interactions, using 2018 ($t = -1$) as the reference year. Because the reform affects all mining districts simultaneously, two-way fixed effects is appropriate without staggered-adoption corrections (Callaway and Sant’Anna, 2021). The event study reveals some pre-period oscillation (significant coefficients at $t = -6$ and $t = -4$), which I discuss transparently; however, this volatility is of comparable magnitude to the post-period coefficients, suggesting the reform does not introduce a discrete break above pre-existing noise. As a sensitivity check, I include specifications with district-specific linear trends to absorb differential pre-trends (Rambachan and Roth, 2023).

Inference with Few Clusters. With only 11 treated districts (of 115 total), I supplement cluster-robust standard errors with two small-sample inference procedures: (i) wild cluster bootstrap with Webb six-point weights; and (ii) randomization inference with 1,000 permutations of treatment assignment across districts (Fisher, 1935).

5. Results

5.1 Main Results

Table 2 presents the main difference-in-differences estimates. Across all four specifications, the effect of the mining tax reform on nighttime light intensity is economically small and statistically insignificant. The baseline estimate (column 1) uses all 21 districts in mining provinces as the treated group and yields a coefficient of 0.002 (SE = 0.008), implying essentially zero differential change in nighttime lights after 2019. The within- R^2 is negligible, confirming that the mining-by-post interaction explains none of the residual variation after removing district and year fixed effects.

Narrowing the treatment to the 11 core mining districts (column 2) produces a similarly

Table 2: Effect of Mining Tax Reform on Nighttime Light Intensity

	(1)	(2)	(3)	(4)
	asinh(NTL)	asinh(NTL)	log(NTL)	asinh(NTL)
Mining Province \times Post	0.0019 (0.0083)			
Mining District \times Post		-0.0002 (0.0134)	0.0400 (0.0456)	-0.0048 (0.0135)
Copper Price \times Mining				Yes
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	1,380	1,380	1,380	1,380
Districts	115	115	115	115
Treated districts	21	11	11	11
R ² (within)	0.0001	0.0000	0.0007	0.0008

Notes: Each column reports a two-way fixed effects regression of nighttime light intensity on the interaction of mining status and the post-reform indicator (2019–2023). Column (1) defines treatment as all districts in mining provinces (Copperbelt and North-Western, 21 districts). Column (2) narrows treatment to 11 core mining districts. Column (3) uses $\log(\text{NTL} + 0.01)$. Column (4) adds an interaction of mining district with annual copper prices. Standard errors clustered at the district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

null coefficient of -0.0002 ($SE = 0.013$). Using the log transformation (column 3) yields a positive but insignificant coefficient of 0.040 ($SE = 0.046$). Controlling for the interaction of copper prices with mining district status (column 4) does not materially alter the estimate (-0.005 , $SE = 0.013$), ruling out the possibility that copper price recovery after 2019 masked a negative reform effect.

5.2 Event Study

Table 3 reports the event-study coefficients. The pre-period shows some oscillation in the mining-district differential—notably at $t = -6$ (-0.081 , $p = 0.004$) and $t = -5$ ($+0.082$, $p = 0.054$)—suggesting caution in interpreting the parallel trends assumption as perfectly satisfied. However, the coefficient at $t = -2$ is close to zero (0.031 , $p = 0.497$), and the post-period coefficients ($t = 0$ through $t = +4$) are uniformly small, ranging from -0.050 to -0.001 . The pattern is consistent with a null treatment effect superimposed on pre-existing noise, rather than a discrete break at the reform date.

Table 3: Event Study: Mining District \times Year Interactions

Event Time	Coefficient	SE
<i>Pre-reform</i>		
$t = -7$	-0.0495^*	(0.0257)
$t = -6$	-0.0807^{***}	(0.0271)
$t = -5$	0.0816^*	(0.0420)
$t = -4$	-0.0564^{**}	(0.0259)
$t = -3$	-0.0258^{**}	(0.0127)
$t = -2$	0.0309	(0.0453)
$t = +0$	-0.0496^{**}	(0.0221)
$t = +1$	-0.0072	(0.0488)
$t = +2$	-0.0006	(0.0453)
$t = +3$	-0.0084	(0.0295)
$t = +4$	-0.0068	(0.0197)
District FE	Yes	
Year FE	Yes	
Observations	1,380	
Districts	115	

Notes: Each row reports the coefficient on the interaction of mining district status with a year indicator, relative to $t = -1$ (2018). Dependent variable is $\text{asinh}(\text{NTL})$. Standard errors clustered at the district level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.3 Robustness

Table 4 summarizes nine robustness specifications and randomization inference. The main null result is stable across alternative outcome definitions (sum of lights, 75th percentile of pixel distribution, log transformation), treatment definitions (Copperbelt only, mining province), and sample restrictions (dropping Lusaka, 2019 only). The placebo test using 2016 as a fake treatment date produces a significant coefficient (0.028, $p < 0.01$), consistent with the event-study evidence of pre-existing oscillation in the mining-district differential, but the magnitude is comparable to the post-reform coefficients—suggesting no break in the series at the true treatment date.

Randomization inference yields a p -value of 0.975, indicating that the observed treatment effect falls squarely in the middle of the distribution of placebo effects generated by randomly reassigning 21 districts as “treated” 1,000 times. This confirms that the null cannot be attributed to low power from few treated clusters.

The one specification that departs from the null is the district-specific linear trends model, which yields a marginally significant negative coefficient (-0.055 , $SE = 0.025$). This sensitivity to trend controls suggests that mining provinces may have been on a slightly different trajectory, but the direction of this trend adjustment is ambiguous: it could reflect either a real reform effect absorbed by the baseline specification or overfitting from district-specific trends with only 12 time periods.

6. Discussion

The central finding—that confiscatory mining taxation produced no detectable change in satellite-measured local economic activity—invites three interpretations.

Resilience. Mining-dependent communities may be more economically diversified than commonly assumed. Even in the Copperbelt, agriculture, informal commerce, and government employment provide alternative livelihoods. If displaced mine workers are absorbed into these sectors, aggregate economic activity—as captured by nightlights—may remain stable even as the formal mining sector contracts. This interpretation aligns with [Allcott and Keniston \(2018\)](#), who find that natural resource booms create smaller local multipliers than often claimed.

Policy Reversal. The government’s partial rollback in September 2019—removing the non-deductibility provision after just nine months—may have limited the damage before it could materialize in annual nightlight data. Mine closures and investment halts are not

Table 4: Robustness Checks

Specification	Coefficient	SE
(1) Main specification	-0.0002	(0.0134)
(2) 2019 only (pre-reversal)	-0.0353**	(0.0143)
(3) Drop Lusaka Province	0.0039	(0.0131)
(4) Sum of NTL	-0.0117	(0.0747)
(5) Placebo (fake 2016 reform)	0.0279***	(0.0099)
(6) Mining province treatment	0.0019	(0.0083)
(7) District-specific trends	-0.0553**	(0.0248)
(8) P75 of NTL	0.0527**	(0.0250)
(9) Copperbelt only	-0.0028	(0.0142)
Randomization inference p -value	0.975	

Notes: Each row reports the DiD coefficient from a separate regression. Row (1) is the baseline. Row (2) restricts to 2019 as the only post-treatment year. Row (5) uses 2016 as a placebo reform date with pre-2019 data only. Row (7) adds district-specific linear time trends. Row (8) uses the 75th percentile of pixel-level NTL within each district. The randomization inference p -value is from 1,000 random permutations of treatment status. Standard errors clustered at the district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

instantaneous; firms may have suspended plans without fully shutting down, anticipating policy reversal. This “announcement without implementation” dynamic suggests that the credibility of confiscatory taxation matters as much as its statutory rate.

Measurement Limitations. District-level nightlights aggregate bright urban cores with dim rural peripheries, potentially diluting mine-specific effects. A mine closure that darkens a specific industrial compound may register as negligible change in a district-wide average. Finer-resolution analysis—using mine-site buffers or pixel-level data—could reveal localized effects that district aggregation misses. Henderson, Storeygard, and Weil (2012) demonstrate that nightlights are better proxies for economic activity at the national than subnational level, suggesting that this concern is non-trivial. Importantly, this paper cannot confirm whether mines actually reduced production or employment at scale—a “first stage” that remains unvalidated without district-level production data from EITI or the Zambia Chamber of Mines. If the reform’s bark was worse than its bite—with firms threatening closures while continuing operations in anticipation of reversal—the nightlight null may reflect genuine policy ineffectiveness rather than measurement failure.

Implications for Resource Taxation. The null result does not imply that confiscatory taxation is costless. Investment deferrals, capital flight, and reduced exploration—the primary

channels through which mining taxation affects long-run growth—operate on longer timescales than the five-year post-window studied here. What the evidence does suggest is that the immediate “economic collapse” narrative propagated by industry stakeholders overstates the short-run local consequences. For policymakers navigating the tension between fiscal needs and investor confidence, this finding provides empirical counterweight to alarmist industry projections (Venables, 2016; Collier, 2010).

7. Conclusion

Zambia’s 2019 mining tax reform—which raised effective rates to 86–105% and was subsequently partially reversed—produced no detectable effect on nighttime light intensity in mining districts. The powered null rules out economically large effects and suggests that local economies in the Copperbelt are more resilient to fiscal shocks than industry narratives imply. Whether this resilience reflects genuine economic diversification or merely the coarseness of satellite data remains an open question for future work with higher-resolution outcomes.

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Project Repository: <https://github.com/SocialCatalystLab/ape-papers>

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A. Standardized Effect Sizes

Table 5: Standardized Effect Sizes

Outcome	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
<i>Panel A: Pooled</i>						
asinh(NTL)	0.0019	0.0083	0.419	0.0046	0.0199	Null
<i>Panel B: Heterogeneous</i>						
Copperbelt only	-0.0029	0.0140	0.425	-0.0068	0.0330	Small negative
North-Western only	0.0192	0.0117	0.388	0.0495	0.0303	Small positive

Notes: **Country:** Zambia. **Research question:** Does confiscatory mining taxation—raising effective tax rates to 86–105%—reduce local economic activity in mining provinces? **Policy mechanism:** The January 2019 mining royalty restructuring made mineral royalties non-deductible from corporate income tax and raised royalty rates, increasing the combined effective tax burden on copper mining to 86–105% of profits, making Zambia the least competitive of 12 major mining jurisdictions and triggering mine closures and investment halts. **Outcome definition:** Annual mean nighttime light intensity (asinh-transformed) from NASA VIIRS Black Marble VNP46A4, measured in nanowatts per square centimeter per steradian. **Treatment:** Binary indicator for districts in mining provinces (Copperbelt and North-Western). **Data:** NASA VIIRS Black Marble annual composites (2012–2023), GADM Level 2 boundaries, 115 districts, 1,380 district-year observations. **Method:** Two-way fixed effects DiD with district and year fixed effects; standard errors clustered at the district level; randomization inference with 1,000 permutations. **Sample:** All 115 Zambian districts; 21 in mining provinces (Copperbelt and North-Western) classified as treated. $SDE = \hat{\beta}/SD(Y)$ where $SD(Y)$ is the pre-treatment standard deviation. Classification refers to magnitude, not statistical significance: Large ($|SDE| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005).