

Explosive Diversification: Organized Crime Adaptation to Mexico's Crackdown on Fuel Theft

Itzel De Haro
University of Navarra

Erik Katovich
University of Connecticut

European Economic Association

August 26th, 2025

Motivation

Oil theft from pipelines is a global problem

- ▶ Worldwide, US\$11 billion stolen annually (~200 million barrels in 2015)
- ▶ Oil theft funds armed groups in Mexico, Nigeria, Syria, Indonesia, Russia

Motivation

Oil theft from pipelines is a global problem

- ▶ Worldwide, US\$11 billion stolen annually (~200 million barrels in 2015)
- ▶ Oil theft funds armed groups in Mexico, Nigeria, Syria, Indonesia, Russia

Cartels target pipeline infrastructure in Mexico

- ▶ US\$3.5 billion lost to oil theft in 2021
- ▶ 186,000 barrels of refined oil and gas are stolen daily
- ▶ Stolen oil and gas accounts for 19% of total national consumption

This paper

Objective: Analyze direct and spillover effects of a 2019 military crackdown on oil theft

Direct effect on targeted municipalities

- ▶ Did the crackdown achieve its immediate aim of reducing oil theft, violence, and cartel activity in municipalities with **oil pipelines**?

Spillover effects

- ▶ Did the crackdown inadvertently lead cartels to substitute toward theft from less-policed **gas pipelines**?
- ▶ Did diversification toward gas theft increase homicides and cartel presence in gas pipeline areas?

Contributions

- ▶ **Behavior and impacts of organized criminal groups**
 - ▶ Infiltration in legal business and lower economic growth
(De Haro, 2024; Blattman et al., 2023; Fenizia and Saggio, 2024; Mirenda, 2022)

- ▶ **Unintended consequences of law enforcement efforts**
 - ▶ Mexico's war against drugs (Herrera & Martinez-Alvarez, 2022; Jones, 2013; Magaloni et al., 2020; Dell, 2015; Lopez Cruz & Torrens, 2023; Battiston et al., 2024)
 - ▶ Conflict minerals in Congo (Parker and Vadheim, 2017)
 - ▶ Mahogany prohibition in Brazil (Chimeli and Soares, 2017)

- ▶ **Crime related to extractive industries**
(Angrist and Kugler, 2008; Berman et al., 2017; Dube and Vargas, 2013)
 - ▶ Oil thefts in Mexico and Nigeria (Lopez Cruz and Torrens, 2023; Battiston et al., 2024; Rexer, 2023)

Context: Mexico's 2019 crackdown on oil theft

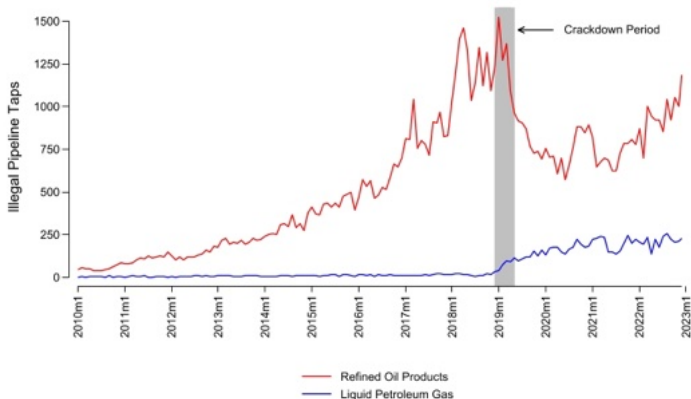
- ▶ Cartels diversified into oil theft after the War on Drugs began in 2006 (Lopez Cruz and Torrens, 2023; Battiston et al., 2024)
- ▶ Fuel theft requires collaboration of pipeline operators
 - ▶ Location of pipelines
 - ▶ Timing of fuel distribution
 - ▶ Technical skills to perforate the pipelines
- ▶ Consumers include gas stations, factories, and transportation businesses



Context

In December 2018, the federal government launched a crackdown against fuel theft

- ▶ Shutdown of high-theft fuel pipelines (December 2018 - April 2019) ▶ Fuel price
- ▶ Increased military surveillance along pipelines

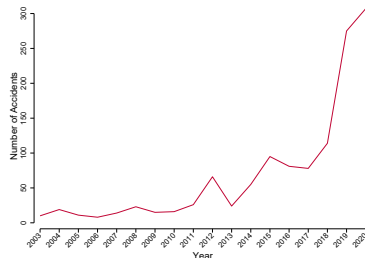


LPG theft arose following the crackdown on oil theft

- ▶ By 2022, 50,000 tons of Liquefied petroleum gas (LPG) were stolen monthly (7.6% of national consumption)
- ▶ US\$600 million in losses in 2019
- ▶ 79% of Mexican households use LPG for cooking and heating
- ▶ **Gas theft is difficult:** it requires specialized equipment, skills, and deeper collaboration with pipeline operators
- ▶ **Gas theft is dangerous:** 600% increase in gas-related accidents in 2019



Gas-Related Accidents



Conceptual framework

- ▶ Battiston et al. (2024): Cartels behave as profit-maximizing firms who choose to produce in original illicit sector or diversify into new sector
- ▶ Crackdown raises costs of operating in original sector, prompting cartels with lower costs of entry to diversify
- ▶ **Costs of entry vary depending on *spatial and technological overlap* between original and new sectors**

Conceptual framework

- ▶ Battiston et al. (2024): Cartels behave as profit-maximizing firms who choose to produce in original illicit sector or diversify into new sector
- ▶ Crackdown raises costs of operating in original sector, prompting cartels with lower costs of entry to diversify
- ▶ **Costs of entry vary depending on *spatial and technological overlap* between original and new sectors**
- ▶ Drug trafficking and oil theft had little overlap \implies entry into oil theft favored newcomers (Battiston et al., 2024)

Conceptual framework

- ▶ Battiston et al. (2024): Cartels behave as profit-maximizing firms who choose to produce in original illicit sector or diversify into new sector
- ▶ Crackdown raises costs of operating in original sector, prompting cartels with lower costs of entry to diversify
- ▶ **Costs of entry vary depending on *spatial and technological overlap* between original and new sectors**
- ▶ Drug trafficking and oil theft had little overlap \implies entry into oil theft favored newcomers (Battiston et al., 2024)
- ▶ Oil theft to gas theft had high spatial and technological overlap \implies entry into gas theft favored incumbents, which have **accumulated experience in pipeline tapping and control of pipeline territories**

Data: municipality-year panel (2015-2022)

Energy infrastructure:

- ▶ Location of oil and gas pipelines, oil refineries, and gas compression centers (National Commission of Hydrocarbons, CNH)

Illegal taps on refined oil and gas pipelines:

- ▶ Monthly reports by municipality (Pemex)

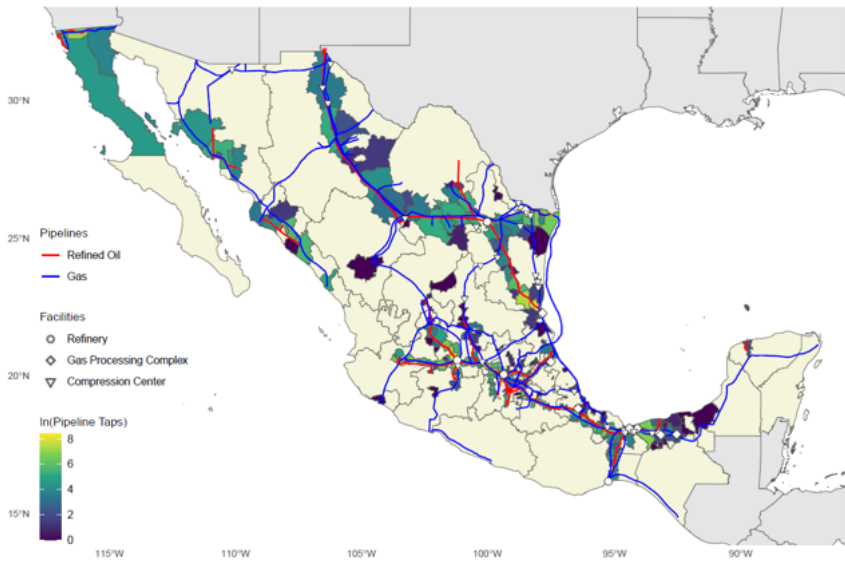
Crime data:

- ▶ Deaths certificates (SINAIS) and crime reports (Ministry of Public Security)

Cartel Presence:

- ▶ Presence of each cartel in each municipality-year (Mapping Criminal Organizations project)

Mexico: Refined Oil and Gas Processing and Transportation Infrastructure



Difference-in-differences estimation:

$$Y_{it} = \alpha_i + \tau_t + \delta(P_i^G \times Post_{t \geq 2019}) + \gamma(P_i^O \times Post_{t \geq 2019}) + e_{it}$$

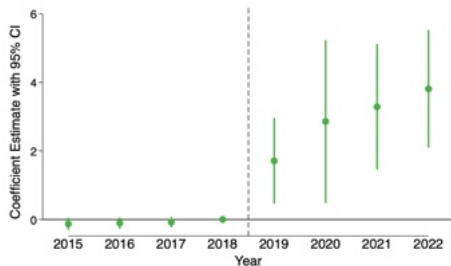
- ▶ Y_{it} : outcome in municipality i in year t
- ▶ P_i^G : gas pipeline present
- ▶ P_i^O : oil pipeline present
- ▶ $Post_{t \geq 2019}$: period after 2019
- ▶ α_i and τ_t : municipality and year fixed effects

Identification:

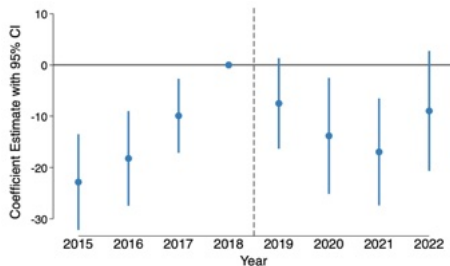
- ▶ Treatment is **endogenous** for oil pipeline municipalities – targeted by crackdown due to worsening crime indicators
- ▶ Treatment is **exogenous** for gas pipeline municipalities – affected indirectly due to spillovers from the crackdown

Crackdown effects on pipeline thefts

(a) Gas thefts

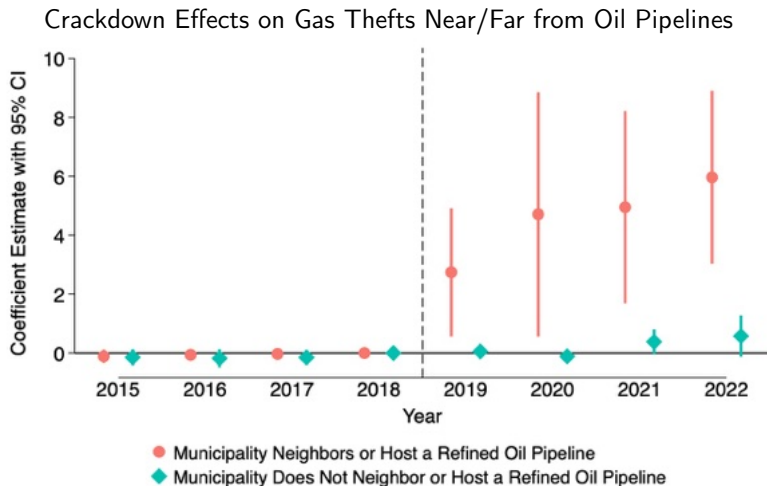


(b) Refined oil thefts



Note: Estimating equation: $Y_{it}^f = \alpha_i + \tau_t + \sum_{y \neq 2018} \beta_y^f P_i^f \times I(t = y) + w_{it}$. Standard errors are clustered at the municipality level.

Gas thefts concentrated near oil pipelines – easier spatial substitution



Crackdown effects on homicides

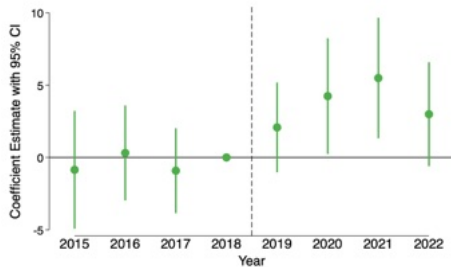
	All (1)	Male (2)	Female (3)	Pemex (4)	Cartel (5)	Military (6)
Gas pipeline × Post 2019	4.054*** (1.540)	3.491** (1.423)	0.355 (0.231)	-0.007 (0.011)	2.125** (0.886)	0.036 (0.059)
Refined oil pipeline × Post 2019	4.222 (2.658)	3.796 (2.437)	0.253 (0.308)	-0.018 (0.024)	1.408 (1.575)	0.054 (0.107)
Observations	19648	19648	19648	19648	19648	19648
Adj. R-squared	0.356	0.355	0.076	0.175	0.325	0.041
Mean dep. var.	21.31	18.87	2.30	0.02	8.58	0.05

Note: Dependent variables measured as homicides per 100,000 inhabitants. Homicides of Pemex employees are estimated based on homicides of individuals of working age (18-60 years old) insured through Pemex. Potential cartel-related homicides are males aged 18-40, killed by a firearm. Homicides of military personnel are estimated based on individuals insured through SEDENA, ages 18-60, killed by a firearm. Municipality and year-fixed effects are included in all specifications. Clustered standard errors at the municipality level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

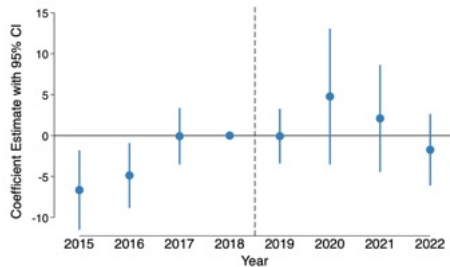
- ▶ Homicides in gas municipalities increased by 19%

Dynamic crackdown effects on homicide rates

(a) Gas pipeline municipalities



(b) Refined oil pipeline municipalities



Crackdown effects on cartel presence

	Number of Cartels		
	All (1)	Oil Theft Specialized (2)	Non-Oil Theft Specialized (3)
Gas pipeline × Post 2019	0.360*** (0.090)	0.230*** (0.048)	0.130** (0.060)
Refined oil pipeline × Post 2019	0.957*** (0.154)	0.282*** (0.071)	0.675*** (0.118)
Observations	17311	17311	17311
Adj. R-squared	0.884	0.819	0.867
Mean dep. var.	2.024	1.164	0.860

Notes: Clustered standard errors at the municipality level in parentheses. Columns (1) - (3) are the number of cartels present in a municipality. Municipality and year-fixed effects are included in all specifications. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

► Cartel presence in gas municipalities increased by 18%

► [Event studies](#) ► [Results by cartel type](#) ► [Homicides increased only where number of cartels grew](#)

Effect on other crimes

	Robberies (1)	Kidnap (2)	Threats & Extortion (3)	Non-lethal Violence (4)
Gas pipeline × Post 2019	0.722 (8.472)	-0.287* (0.151)	3.281 (2.869)	6.105** (3.021)
Refined oil pipeline × Post 2019	-49.28*** (12.926)	-0.345 (0.244)	0.228 (3.999)	-14.09*** (4.249)
Observations	19648	19648	19648	19648
Adj. R-squared	0.838	0.119	0.526	0.736
Mean dep. var.	204.4	0.786	49.83	95.57

Notes: This table reports the results for Equation 11. Dependent variables are measured as crimes per 100,000 inhabitants. Non-lethal violence consists of injuries and other crimes that threaten life. Municipality and year-fixed effects are included in all specifications. Clustered standard errors at the municipality level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- ▶ Increase in non-lethal violence (crimes that threaten life) in gas pipeline municipalities

Spillover violence to neighboring non-pipeline municipalities

	All (1)	Male (2)	Female (3)	Pemex (4)	Cartel (5)	Military (6)
Neighbor with gas pipeline × Post 2019	-1.303 (1.773)	-1.593 (1.647)	0.267 (0.323)	-0.00678 (0.007)	-0.621 (0.886)	0.00803 (0.027)
Neighbor with refined oil pipeline × Post 2019	5.806** (2.369)	5.631*** (2.125)	-0.0226 (0.449)	0.00294 (0.007)	2.091* (1.190)	0.0819 (0.068)
Observations	14352	14352	14352	14352	14352	14352
Adj. R-squared	0.327	0.331	0.0567	0.100	0.294	0.00214
Mean dep. var.	19.56	17.33	2.141	0.00461	7.570	0.0372

Notes: This table estimates spillover effects on municipalities that share a border with a municipality that has a gas or a refined oil pipeline. The sample is restricted to municipalities with no refined oil or gas pipeline. Dependent variables measured as homicides per 100,000 inhabitants. Homicides of Pemex employees are estimated based on homicides of individuals of working age (18-60 years old) insured through Pemex. Potential cartel-related homicides are males aged 18-40, killed by a firearm. Homicides of military personnel are estimated based on individuals insured through SEDENA, ages 18-60, killed by a firearm. Municipality and year-fixed effects are included in all specifications. Clustered standard errors at the municipality level in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- ▶ Homicides increased by 30% in oil pipeline neighbors (excluding gas pipeline municipalities)

Robustness Checks

- ▶ Exclude neighbors to avoid spillover contamination of control group:

- ▶ Homicides w/o neighbors

- ▶ Match municipalities on state and baseline characteristics before DID:

- ▶ Matching: Homicides

- ▶ Matching: Cartel presence

- ▶ Control for municipal COVID-19 rates:
 - ▶ Control for Covid

- ▶ Leave-one-out analysis (by state):
 - ▶ Leave-one-out: Taps
 - ▶ Leave-one-out: Homicides

- ▶ Leave-one-out: Cartel Presence

- ▶ Rambachan and Roth (2023):
 - ▶ honestdid

Conclusion

- ▶ The crackdown provoked cartel diversification into a new and even more dangerous activity – gas theft
- ▶ Diversification into gas theft was concentrated near oil pipelines and driven by cartels with previous experience in oil theft
- ▶ The crackdown increased cartel presence by 19% and homicide rates by 18% in municipalities hosting gas pipeline infrastructure

Policy Implications

- ▶ Anticipate diversification into spatially and technologically overlapping sectors
- ▶ Decentralized monitoring entity to avoid infiltration
- ▶ Increase monitoring of fuel and gas retailers

Thank you!

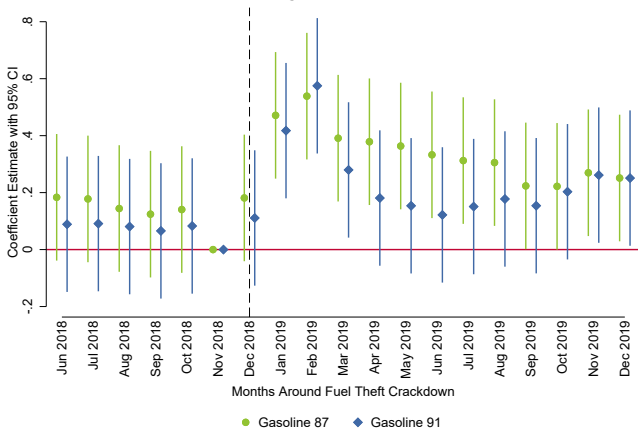
Any comments, suggestions, ideas:
ideharo@unav.es

Shutdown of high-theft pipelines

- ▶ Transportation of fuel on tanker trucks
- ▶ Fuel shortages on targeted states
- ▶ Massive explosion killed 137 people who attempted to collect fuel in jerrycans from a ruptured pipeline (January 19, 2019 – Tlahuelilpan, Hidalgo)



Crackdown Effects on Gasoline Prices in Affected States

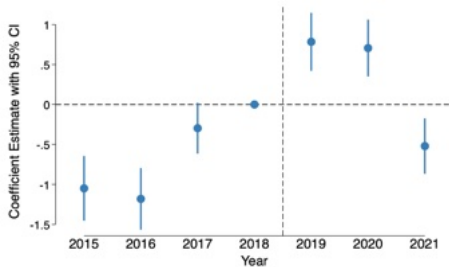
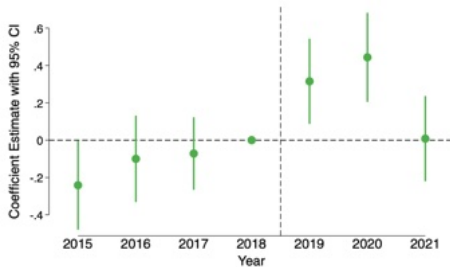


Note: Estimating equation: $Y_{st} = \delta_s + \gamma_t + \sum_{t \neq 12/18} \beta_t T_{st} + \epsilon_{st}$. Y_{st} . T_{st} indicates affected states: Hidalgo, México, Jalisco, Michoacán de Ocampo, Guanajuato, Querétaro, and Aguascalientes. Gasoline prices from CRE.

Dynamic Crackdown Effects on Cartel Presence

(a) Gas Pipeline Municipalities

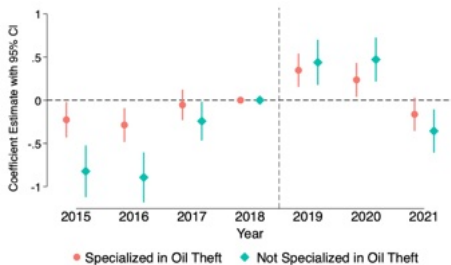
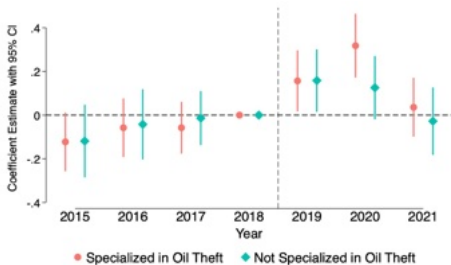
(b) Refined Oil Pipeline Municipalities



Crackdown Effects on Cartel Presence by Cartel Type

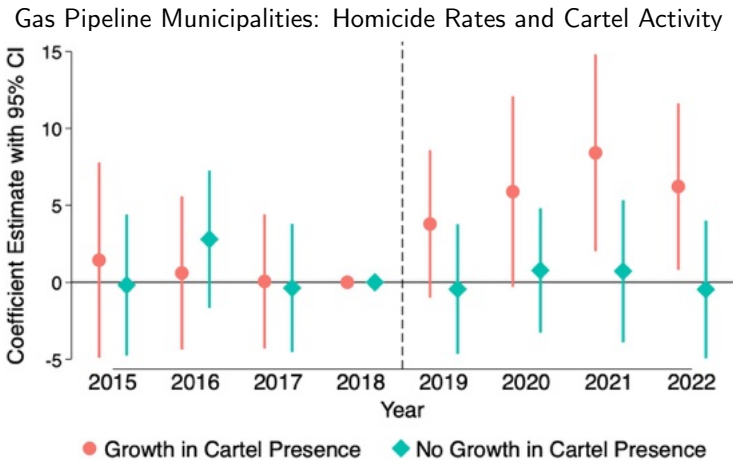
(a) Gas pipeline municipalities

(b) Refined oil pipeline municipalities



► Expansion of specialized oil-theft cartels in gas municipalities

Homicides increased where cartel presence increased



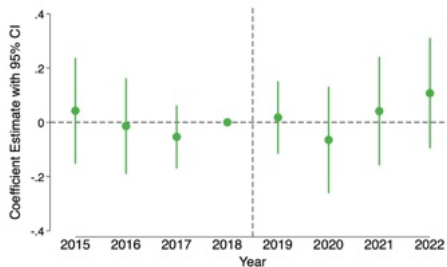
Disaggregated results on robberies

	Home & Business (1)	Highway & Street (2)	Machinery (3)	Other (4)
Gas pipeline × Post 2019	-1.429 (2.878)	1.026 (4.714)	1.046*** (0.283)	2.201 (3.408)
Refined oil pipeline × Post 2019	-6.933 (4.913)	-22.45*** (7.569)	-0.521 (0.366)	-18.22*** (5.017)
Observations	19648	19648	19648	19648
Adj. R-squared	0.752	0.792	0.146	0.740
Mean dep. var.	48.13	80.80	1.255	65.83

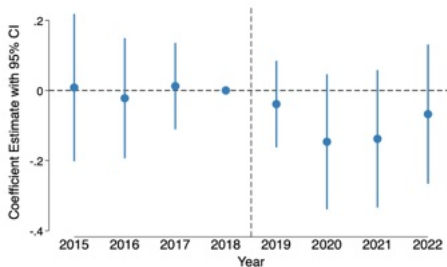
Notes: Dependent variables are measured as crimes per 100,000 inhabitants. Municipality and year-fixed effects are included in all specifications. Clustered standard errors at the municipality level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Crackdown Effects on the Share of Population with Formal Employment

(a) Gas Pipeline Municipalities

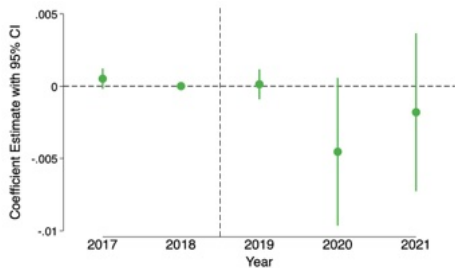


(b) Oil Pipeline Municipalities

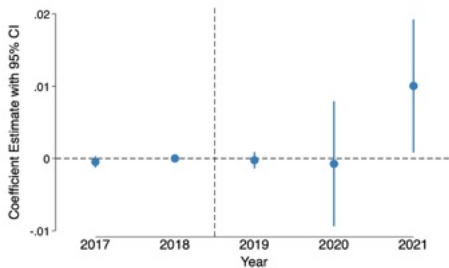


Crackdown Effects on the Share of Population Enrolled in Higher Education

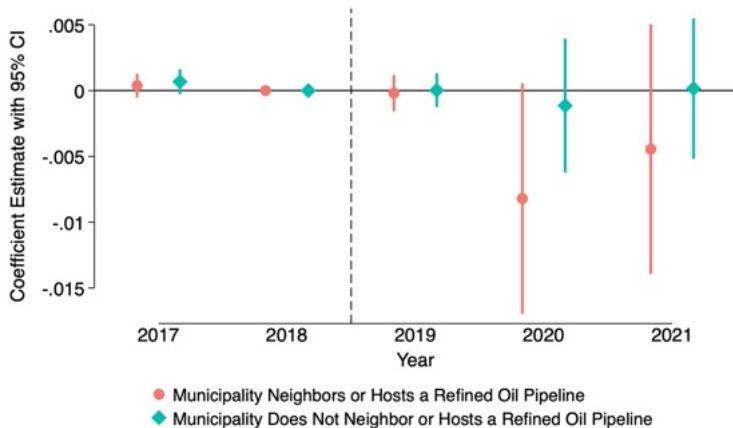
(a) Gas Pipeline Municipalities



(b) Oil Pipeline Municipalities



Crackdown Effects on Enrollment in Higher Education in Gas Pipelines Municipalities, Decomposed by Neighboring/Not-Neighboring an Oil Pipeline



Robustness Check: Estimates on homicides excluding neighbors

	All (1)	Male (2)	Female (3)	Pemex (4)	Cartel (5)	Military (6)
Gas pipeline × Post 2019	4.329*** (1.555)	3.756*** (1.439)	0.341 (0.234)	-0.007 (0.011)	2.192** (0.895)	0.045 (0.059)
Refined oil pipeline × Post 2019	4.359 (2.663)	3.928 (2.442)	0.246 (0.309)	-0.018 (0.025)	1.442 (1.578)	0.058 (0.107)
Observations	18088	18088	18088	18088	18088	18088
Adj. R-squared	0.365	0.360	0.077	0.177	0.321	0.050
Mean dep. var.	21.29	18.88	2.27	0.02	8.59	0.05

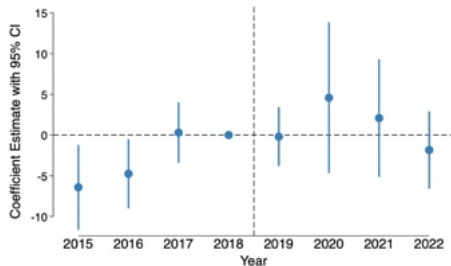
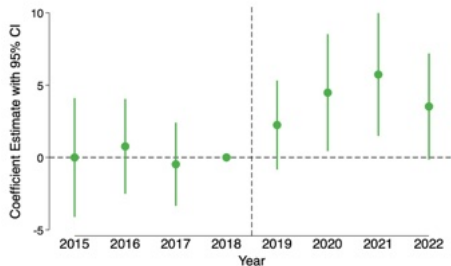
Notes: This table reports the estimates for homicides in a subsample with no-neighboring municipalities. Dependent variables measured as homicides per 100,000 inhabitants. Homicides of Pemex employees are estimated based on homicides of individuals of working age (18-60 years old) insured through Pemex. Potential cartel-related homicides are males aged 18-40, killed by a firearm. Homicides of military personnel are estimated based on individuals insured through SEDENA, ages 18-60, killed by a firearm. Municipality and year-fixed effects are included in all specifications. Clustered standard errors at the municipality level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Robustness Check: Matching

Homicides

(a) Gas pipeline municipalities

(b) Refined oil pipeline municipalities



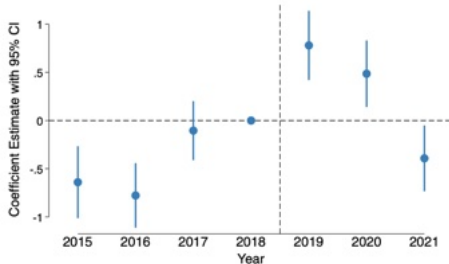
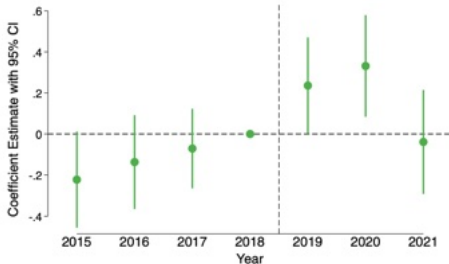
Note: Sample is restricted to treated municipalities and control municipalities that exactly match on state and quintiles of pre-treatment (2015–2018) homicide rates per 100,000 residents, number of active cartels, formal employment share of the population, income level, and population.

Robustness Check: Matching

Number of cartels

(a) Gas pipeline municipalities

(b) Refined oil pipeline municipalities



Note: Sample is restricted to treated municipalities and control municipalities that exactly match on state and quintiles of pre-treatment (2015–2018) homicide rates per 100,000 residents, number of active cartels, formal employment share of the population, income level, and population.

Robustness Check: Controlling for Covid-19 rates

Table A10: Results Controlling for COVID

	Homicides			Number of Cartels		
	All	Male	Cartel	All	Huachicol Specialized	Non-Huachicol Specialized
	(1)	(2)	(3)	(4)	(5)	(6)
Gas pipeline × Post 2019	3.989*** (1.537)	3.441** (1.420)	2.082** (0.883)	0.363*** (0.090)	0.232*** (0.048)	0.131** (0.060)
Refined oil pipeline × Post 2019	3.829 (2.737)	3.496 (2.511)	1.150 (1.622)	0.958*** (0.155)	0.286*** (0.072)	0.672*** (0.118)
Observations	19648	19648	19648	17199	17199	17199
Adj. R-squared	0.356	0.355	0.325	0.884	0.819	0.867
Mean dep. var.	21.31	18.87	8.58	2.03	1.17	0.86

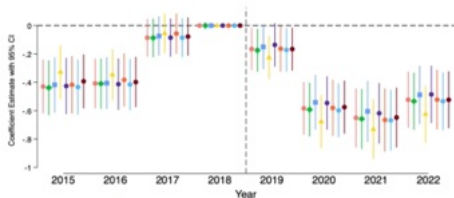
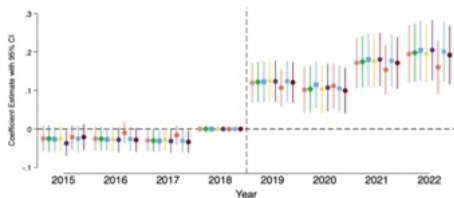
Notes: This table reports the results controlling for the reported number of covid cases per capita at the municipality-year level. Columns (1-3) show results on the homicide rates per per 100,000 inhabitants. Potential cartel-related homicides are males aged 18-40, killed by a firearm. Columns (4-6) report the results on the total number of active cartels. Dependent variable measures in Columns (5) and (6) measure presence on fuel-specialized cartels and non-fuel theft specialized cartels, respectively, where fuel-theft specialized cartels are identified from [Etelekt Consultores \(2016\)](#), [Langner \(2017\)](#), [Castillo \(2021\)](#), and [González \(2020\)](#). Municipality and year-fixed effects are included in all specifications. Clustered standard errors at the municipality level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Leave-One-Out Analysis: Event Studies Excluding Targeted States

A. Pipeline Thefts

(a) Gas Pipelines

(b) Oil Pipelines



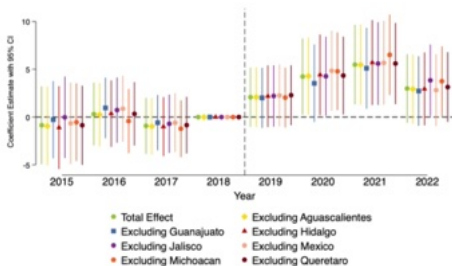
- Total Effect
- Excluding Aguascalientes
- Excluding Guanajuato
- Excluding Hidalgo
- Excluding Jalisco
- Excluding Mexico
- Excluding Michoacan
- Excluding Queretaro

- Total Effect
- Excluding Aguascalientes
- Excluding Guanajuato
- Excluding Hidalgo
- Excluding Jalisco
- Excluding Mexico
- Excluding Michoacan
- Excluding Queretaro

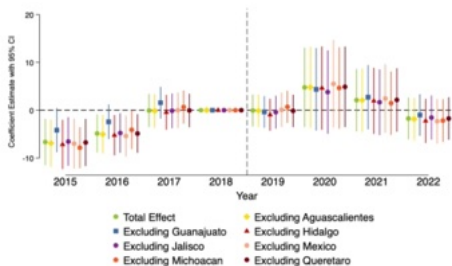
Leave-One-Out Analysis: Event Studies Excluding Targeted States

B. Homicides

(c) Gas Pipeline Municipalities



(d) Oil Pipeline Municipalities

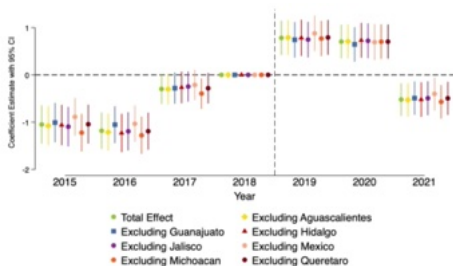
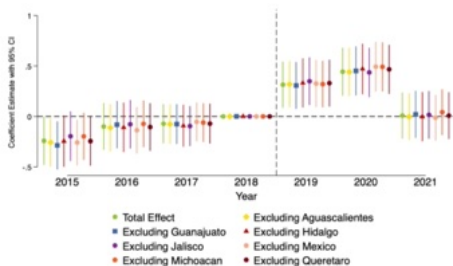


Leave-One-Out Analysis: Event Studies Excluding Targeted States

C. Number of Cartels

(e) Gas Pipeline Municipalities

(f) Oil Pipeline Municipalities



Rambachan and Roth – Pre-Trend Violations

