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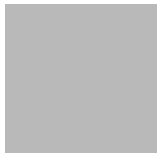
CHICAGO HARRIS
PUBLIC POLICY | THE UNIVERSITY OF CHICAGO




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Rebel attacks against energy infrastructure in Colombia

AIEE Energy Symposium 30 November – 2 December 2016
Current and Future Challenges to Energy Security



- 
- Intentional attacks influence on energy supply & security
 - Impact of intentional attacks
 - Background of Colombian rebels & energy infrastructure attacks
 - Motivation of attacks
 - Research question & design
 - Results & discussion

Impact of intentional attacks on energy infrastructures

- 
- Interrupt supply
 - Increase operating costs → reduce profits
 - Repairing damaged infrastructures
 - Securing infrastructures & employees
 - Discourage foreign investment in resource development & extraction
 - Complicate local operations
 - Increase risk of financial return
 - Compromise safety of employees
 - Consequences can be widespread & long lasting

Civil conflict environment in Colombia

- Two main rebel groups:
 - Las Fuerzas Armadas Revolucionarias de Colombia (FARC)
 - Ejército de Liberación Nacional (ELN)
- Two main hypotheses on their motivation:
 - Rapacity/financial gain channel (established)
 - Political gain channel (not yet established)



Figure left: FARC rebel fighters. Figure right: ELN rebel fighters (source: BBC).

Motivation of attacks

- Rapacity/financial gain: the greed hypothesis
 - Control of contested resources → theft & resale profit
 - Extortion of locally operating firms → collection of bribes & taxes
- Political influence & gain
 - Target elections to influence voting participation/electoral outcomes
 - Target election to influence policies

Rebel attacks on energy infrastructures

Research Question: Do FARC and ELN strategically time energy infrastructures attacks around elections to influence political outcomes?

Contribution to literature:

- Use new data to shed light on Colombian civil conflict
- Focus on political value of energy infrastructure targets

Research Design:

- Econometric analysis using fixed schedule national elections as exogenous variation to determine whether rebels strategically time attacks on energy infrastructure

Data sources used in presented results



1. Energy Infrastructure Attack Database (EIAD)

- Our lab developed a database of global, non-state actor energy infrastructure attacks
- Energy infrastructure attack data → outcome variables

2. Centro de Estudios Desarrollo Económico (CEDE)

- Vote counts, candidates, atypical election dates
- Panel municipal characteristics (e.g., population)

3. Colombian National Election Registry

- vote counts, candidates, atypical election dates

4. Oil production data

- 1988 production by municipality, Dube & Vargas (2013)

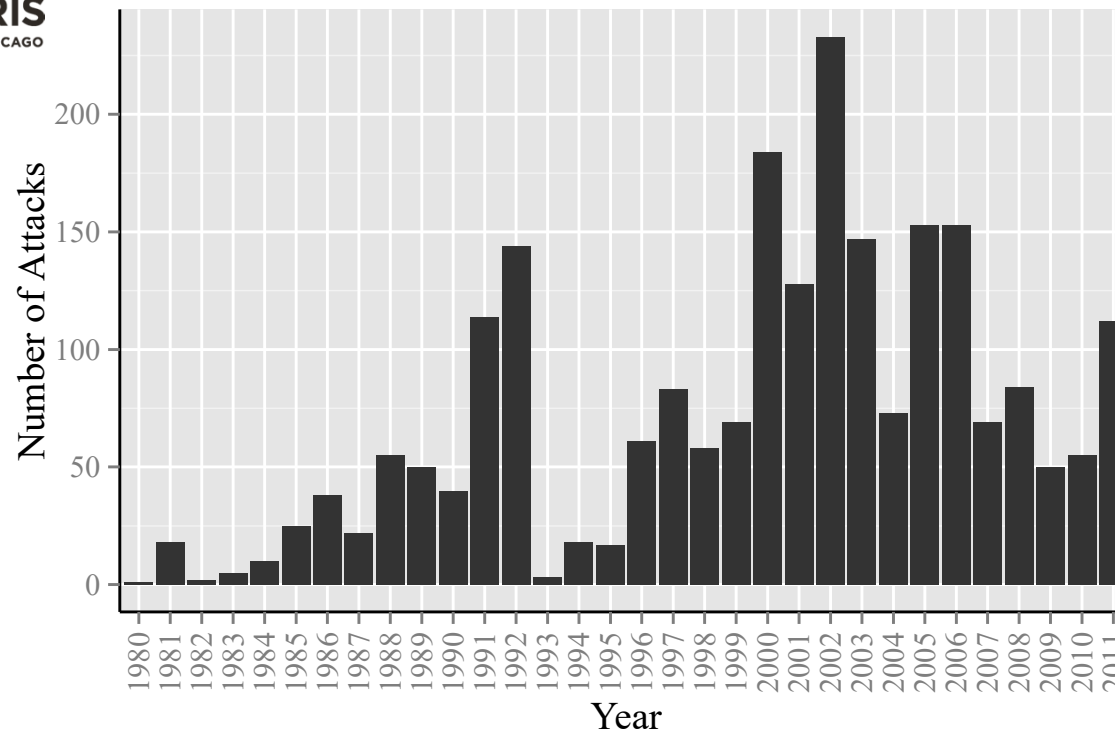
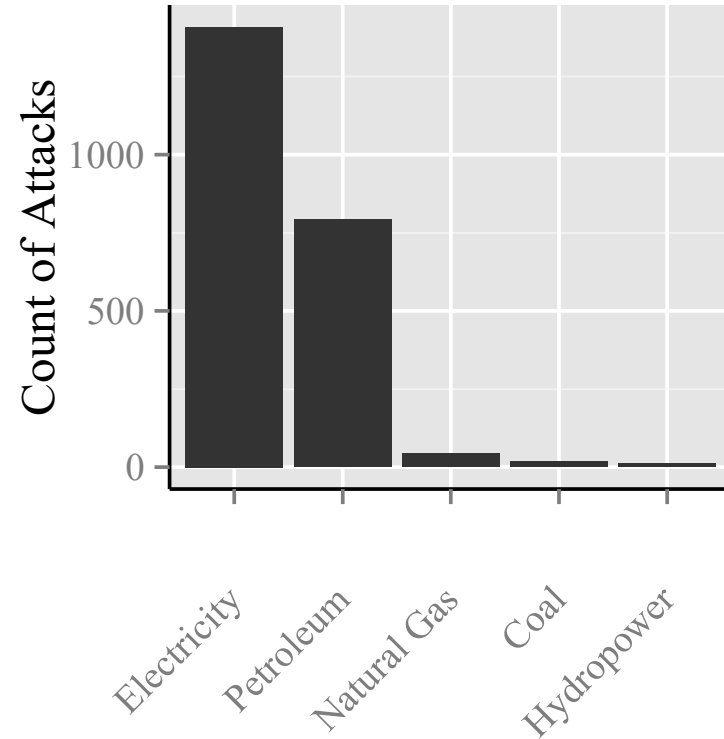
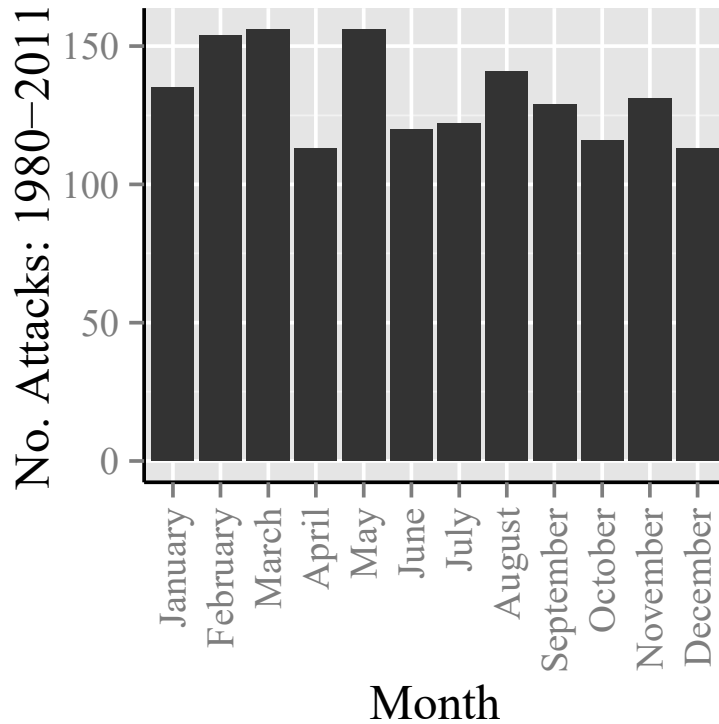


Figure: A histogram of the attacks against energy infrastructure in Colombia between 1980-2011.

Number of Attacks	0 Attacks	1 Attack	2 Attacks	3 Attacks	4 Or More Attacks
	365,531	1,239	263	50	21

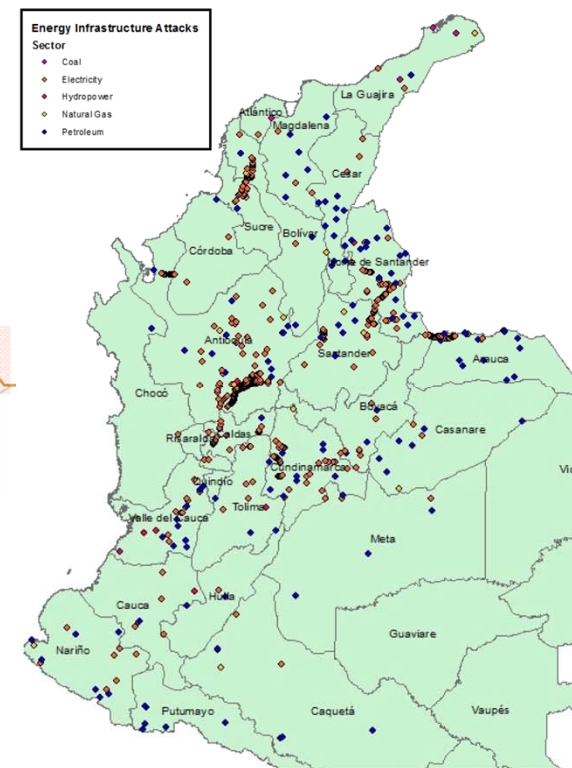
Table : Frequency table of the number of attacks in panel of municipalities between 1980-2011.

EIAD data description continued



Figures: The distribution of attacks by month (left) and the breakdown of attacked energy sectors in Colombia between 1980-2011 (right) (source: EIAD).

Colombian energy infrastructure targets



Figures: Map of major pipelines (left) (source: Ecopetrol). Map of electricity Transmission (center) (source: Global Energy Network Institute). Spatial distribution of energy infrastructure attacks 1980-2011 (right) (source: EIAD).

Weighted Least Squares Linear Model

Estimates linear relationship
between election timing & attacks

Fixed Effects framework



Zero-Inflated Count Model

Non-Linear Model

Estimates non-linear relationship
between election timing & attacks

Fixed Effects framework

Empirical strategy

$$Y_{m,by} = \lambda_m + \gamma_y + \delta_1 \text{elect}_{m,by} + \delta_2 \text{elect}_{m,(b+x)y} + \mathbf{X}_{m,by}\rho + t\phi_1 + t^2\phi_2 + \epsilon_{m,by},$$

- We apply this model to a subset of our data: treated & control observations
- We define the „control“ observations or counterfactual as the 12 months before an election
- Make inference on results with robust, clustered standard errors and bootstrapped errors

Empirical strategy continued

- The zero-inflated negative binomial model is a two-part model:

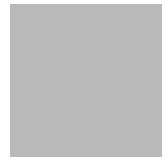
$$g(y) = \begin{cases} f_1(0) + (1 - f_1(0))f_2(0) & \text{if } y = 0 \\ (1 - f_1(0))f_2(y) & \text{if } y \geq 1, \end{cases}$$

$$P(Y_{m,by} = 1 | X_{m,by}) = \frac{\exp(Oil_{m,1988}\rho + KMpipeline_m\phi)}{1 + \exp(Oil_{m,1988}\rho + KMpipeline_m\phi)}$$

- The density of positive attacks, f_2 , is predicted with a negative binomial model using the same covariates as the linear regressions.

$$P(Y_{m,by} = 1 | X_{m,by}) = \frac{\Gamma(\alpha^{-1} + y)}{\Gamma(\alpha^{-1})\Gamma(y + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu} \right)^{-1} \left(\frac{\mu}{\mu + \alpha^{-1}} \right)^y$$

Overall results



40% increase in attacks during election month and 3 months prior relative to the mean

Increases driven by attacks on electricity infrastructures; not driven by attacks on oil infrastructures

National election months 25% more likely to experience attack relative to mean

Statistically significant evidence that rebels strategically time attacks near elections

Presidential elections main driver of results; not driven by attacks on other national elections

Strategic timing of attacks around national elections results

Outcome Variables Treatment Variable	Conflict Month	Number of Attacks	Number of Oil Attacks	Number of Electricity Attacks
National Election Month, δ_1	0.00159** (0.000575)	0.000402** (0.000154)	0.000118 (0.0000928)	0.000296* (0.000129)
National Election in next 3 months, δ_2	0.000693 (0.000475)	0.000369* (0.000155)	0.0000302 (0.0000524)	0.000362** (0.000135)
Observations	199804	199595	199595	199595

Note: These models were generated with a 12 month counterfactual control group on approximated 1980 municipality boundaries (construction of counterfactual and 1980 boundaries explained in data description). Results shown here are with robust bootstrapped errors replicated 400 times. Results with weighted standard errors shown in paper and do not differ significantly from bootstrapped errors. Variables not shown are municipality fixed effects, and year fixed effects. Municipality fixed effects capture time invariant variables like municipality oil production in 1988 and the length of the pipelines in the municipality (we do not have a time evolving measure of pipelines). Bootstrapped robust standard errors in parentheses, clustered by municipality.

*p\$<\$0.05, **p\$<\$0.01, *** p\$<\$0.001

Diapositiva 15

BP4512 As said earlier you do not specify (5) and (6)

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Text below you could also shorten and arrange in bullets.

Finally, spread the content better over the whole slide.

Burgherr Peter; 24/11/2016

Strategic timing of attacks around presidential elections results

Outcome Variables Treatment Variable	Conflict Month	Number of Attacks	Number of Oil Attacks	Number of Electricity Attacks
National Election Month, δ_1	0.00195* (0.000938)	0.0000308 (0.000226)	0.0000108 (0.0000472)	-0.00000314 (0.000213)
National Election next 3 months, δ_2	0.000559 (0.000910)	0.000523** (0.000196)	0.000000935 (0.0000587)	0.000517** (0.000179)
Observations	102292	102185	102185	102185

Note: These models were generated with a 12 month counterfactual control group on approximated 1980 municipality boundaries (construction of counterfactual and 1980 boundaries explained in data description). Results shown here are with robust bootstrapped errors replicated 400 times. Results with weighted standard errors shown in paper and do not differ significantly from bootstrapped errors. Variables not shown are municipality fixed effects, and year fixed effects. Municipality fixed effects capture time invariant variables like municipality oil production in 1988 and the length of the pipelines in the municipality (we do not have a time evolving measure of pipelines). Bootstrapped robust standard errors in parentheses, clustered by municipality.

*p\$<\$0.05, **p\$<\$0.01, *** p\$<\$0.001

Diapositiva 16

BP4513 As said earlier you do not specify (5) and (6)

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Burgherr Peter; 24/11/2016

Preliminary non-linear regression results

	All Elect	Presidential
No. energy infrastructure attacks		
Election month	0.248* (0.110)	0.400 (0.220)
Election next 3 months	0.0808 (0.0824)	0.0830 (0.209)
Observations	199804	102292

Standard errors in parentheses

Both models are zero-inflated negative binomial with a logit link.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

- Results preliminary due to computational intensity of adding covariates – trying to solve this currently
- Find national election months 1.3 times more likely to experience an attack than a non-election month – result consistent with linear model results
- Do not find a presidential effect
 - Inconsistent with linear model results

Diapositiva 17

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Text below you could also shorten and arrange in bullets.

Finally, spread the content better over the whole slide.

Burgherr Peter; 24/11/2016



Conclusions

- Statistically significant evidence that rebels strategically time energy infrastructure attacks near presidential elections – supporting political motive
- Linear model results partially supported by preliminary non-linear model results
- Results highlight the potential value of energy infrastructure as attack targets

Continuing work


- Test hypothesis that attacks on electricity are indirect attacks on oil industry using oil production data
- Test impact of attacks on energy production
- Test impacts of attacks on election outcomes (e.g. voter turnout or elected candidates)

Thank you for
your attention!

Any Questions?

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- A solid grey square is positioned to the left of the list of bullet points.
- Increase in paramilitary presence, increases electoral outcomes to favor paramilitary (Acemoglu et al., 2009)
 - Oil price shocks increase the number of paramilitary sympathetic candidates that are elected (Carreri & Dube, 2015)
 - Price shocks in commodities cause income shocks that differentially affect Colombian civil conflict (Dube & Vargas, 2013)
 - Voter turnout potentially reduced by FARC attacks (Gallego, 2011)
 - Historical rebel violence has non-linear impact on electoral outcomes (Weintraub, 2015)
 - Rebel tactics are influenced by local economic conditions (Wright, 2015)

Appendix version results: national elections

	(1)	(2)	(3)	(4)	(5)	(6)
	Conflict Month	Conflict Month	No. Atks	No. Atks	Oil Atks	Elec Atks
Nat'l election month	0.00143* (0.000618)	0.00159** (0.000575)	0.000383* (0.000152)	0.000402** (0.000154)	0.000118 (0.0000928)	0.000296* (0.000129)
Nat'l election next 3 months	0.000693 (0.000475)	0.000764 (0.000459)	0.000349* (0.000143)	0.000369* (0.000155)	0.0000302 (0.0000524)	0.000362** (0.000135)
WTI dollar per barrel oil	-0.0000183 (0.0000414)	-0.0000178 (0.0000419)	-0.00000959 (0.0000123)	-0.0000110 (0.0000137)	-0.00000768 (0.0000113)	-0.00000392 (0.00000725)
Monetary value of oil production	0.000385 (0.000391)	0.000391 (0.00381)	0.0000252 (0.0000313)	0.0000263 (0.000357)	-0.0000169 (0.0000953)	0.0000420 (0.000306)
Monetary value of KM pipeline	-3.02e-10 (1.56e-10)	-2.99e-10 (1.60e-10)	-4.91e-11** (1.81e-11)	-5.13e-11* (2.24e-11)	-2.31e-11 (1.19e-11)	-2.73e-11 (1.42e-11)
Other election in obs window	-0.00780* (0.00352)	-0.00753* (0.00350)	-0.000956 (0.000826)	-0.000983 (0.000841)	-0.0000523 (0.0000989)	-0.000885 (0.000880)
Linear month trend	-0.000369*** (0.000100)	-0.000366*** (0.0000944)	-0.0000642* (0.0000289)	-0.0000660* (0.0000322)	-0.0000285 (0.0000275)	-0.0000362* (0.0000176)
Quadratic month trend	0.000000363 (0.000000264)	0.000000360 (0.000000251)	4.71e-08 (8.53e-08)	4.97e-08 (9.68e-08)	7.24e-08 (7.69e-08)	-2.21e-08 (5.66e-08)
Observations	199595	199804	199595	199595	199595	199595

Standard errors in parentheses

All standard errors are clustered at the municipality level. Models (1) and (3) are weighted by the natural log of the municipality population. Models (2) and (4) have bootstrapped errors replicated 400 times, and therefore, are not population weighted. Variables not shown are municipality fixed effects, and year fixed effects. Municipality fixed effects capture time invariant variables like municipality oil production in 1988 and the length of the pipelines in the municipality (we do not have a time evolving measure of pipelines).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix version results: presidential

	(1)	(2)	(3)	(4)	(5)	(6)
	Conflict Month	Conflict Month	No. Atks	No. Atks	Oil Atks	Elec Atks
Presidential election month	0.00214* (0.00102)	0.00195* (0.000938)	0.0000401 (0.000225)	0.0000308 (0.000226)	0.0000108 (0.0000472)	-0.00000314 (0.000213)
Presidential election next 3 months	0.000605 (0.000952)	0.000559 (0.000910)	0.000483** (0.000183)	0.000523** (0.000196)	0.000000935 (0.0000587)	0.000517** (0.000179)
WTI dollar per barrel oil	-0.000165 (0.0000887)	-0.000170* (0.0000842)	-0.0000376* (0.0000184)	-0.0000390* (0.0000195)	-0.00000226 (0.00000411)	-0.0000361* (0.0000177)
Monetary value of oil production	-0.000591 (0.000498)	-0.000591 (0.00460)	-0.00000608 (0.0000180)	-0.00000618 (0.000187)	-0.0000543 (0.0000724)	0.0000480 (0.000236)
Monetary value of KM pipeline	-4.81e-11 (1.66e-10)	-5.79e-11 (1.72e-10)	-3.81e-11* (1.50e-11)	-4.04e-11* (1.83e-11)	-1.09e-11 (6.13e-12)	-2.77e-11 (1.51e-11)
Other election in obs window	0.00151 (0.00103)	0.00159 (0.000957)	0.000235 (0.000249)	0.000222 (0.000259)	-0.00000675 (0.0000917)	0.000247 (0.000239)
Linear month trend	-0.000307* (0.000152)	-0.000347* (0.000145)	-0.0000722* (0.0000311)	-0.0000739* (0.0000323)	-0.0000179 (0.0000141)	-0.0000551* (0.0000278)
Quadratic month trend	0.000000414 (0.000000488)	0.000000491 (0.000000452)	0.000000224 (0.000000135)	0.000000235 (0.000000145)	2.56e-08 (3.08e-08)	0.000000207 (0.000000130)
Observations	102185	102292	102185	102185	102185	102185

Standard errors in parentheses

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* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix version results: congressional

	(1)	(2)	(3)	(4)	(5)	(6)
	Conflict Month	Conflict Month	No. Atks	No. Atks	Oil Atks	Elec Atks
Congressional election month	-0.000567 (0.00111)	-0.000446 (0.00107)	0.000115 (0.000328)	0.000131 (0.000350)	0.000128 (0.000218)	0.00000107 (0.000263)
Congressional election next 3 months	-0.00100 (0.000625)	-0.00102 (0.000588)	-0.000195 (0.000177)	-0.000193 (0.000191)	0.0000144 (0.0000731)	-0.000219 (0.000173)
WTI dollar per barrel oil	-0.0000970 (0.0000770)	-0.000101 (0.0000755)	-0.0000364* (0.0000180)	-0.0000385* (0.0000192)	0.00000297 (0.00000662)	-0.0000442* (0.0000176)
Monetary value of oil production	0.000245 (0.000534)	0.000238 (0.00512)	0.0000303 (0.0000188)	0.0000298 (0.000225)	-0.0000474 (0.0000920)	0.0000770 (0.000287)
Monetary value of KM pipeline	-1.97e-10 (2.03e-10)	-2.03e-10 (1.96e-10)	-5.26e-11** (1.89e-11)	-5.58e-11* (2.31e-11)	-1.99e-11* (9.25e-12)	-3.54e-11* (1.77e-11)
Other election in obs window	0.00313 (0.00278)	0.00308 (0.00249)	0.000294 (0.000506)	0.000272 (0.000506)	-0.0000300 (0.000138)	0.000400 (0.000497)
Linear month trend	-0.000159 (0.000124)	-0.000174 (0.000117)	-0.0000417 (0.0000344)	-0.0000431 (0.0000353)	-0.00000589 (0.0000177)	-0.0000367 (0.0000303)
Quadratic month trend	0.000000298 (0.000000460)	0.000000338 (0.000000456)	0.000000159 (0.000000129)	0.000000166 (0.000000133)	-1.39e-09 (3.79e-08)	0.000000184 (0.000000120)
Observations	111735	111852	111735	111735	111735	111735

Standard errors in parentheses

All standard errors are clustered at the municipality level. Models (1) and (3) are weighted by the natural log of the municipality population. Models (2),(4)-(6) have bootstrapped errors replicated 400 times, and therefore, are not population weighted. Variables not shown are municipality fixed effects, and year fixed effects. Municipality fixed effects capture time invariant variables like municipality oil production in 1988 and the length of the pipelines in the municipality (we do not have a time evolving measure of pipelines).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix version results: council

	(1)	(2)	(3)	(4)	(5)	(6)
	Conflict Month	Conflict Month	No. Atks	No. Atks	Oil Atks	Elec Atks
Council election month	0.000474 (0.00191)	0.000826 (0.00185)	-0.000142 (0.000393)	-0.000126 (0.000384)	0.000201 (0.000258)	-0.000212 (0.000282)
Council election next 3 months	0.000864 (0.00129)	0.000837 (0.00123)	-0.000102 (0.000266)	-0.0000963 (0.000264)	0.0000852 (0.000176)	-0.0000975 (0.000203)
WTI dollar per barrel oil	0.0000113 (0.0000647)	0.0000105 (0.0000631)	-0.00000608 (0.0000253)	-0.00000777 (0.0000291)	-0.0000224 (0.0000237)	0.0000129 (0.0000149)
Monetary value of oil production	0.000621 (0.000403)	0.000631 (0.00393)	0.0000331 (0.0000425)	0.0000351 (0.000466)	-0.00000214 (0.000182)	0.0000362 (0.000334)
Monetary value of KM pipeline	-4.83e-10* (2.07e-10)	-4.71e-10* (2.06e-10)	-5.31e-11* (2.44e-11)	-5.47e-11 (2.99e-11)	-3.14e-11 (1.88e-11)	-2.49e-11 (1.64e-11)
Other election in obs window	-0.000139 (0.000837)	-0.0000470 (0.000811)	0.0000314 (0.000284)	0.0000543 (0.000303)	0.000199 (0.000311)	-0.000114 (0.0000659)
Linear month trend	-0.000729* (0.000322)	-0.000731* (0.000315)	-0.000137 (0.000114)	-0.000146 (0.000129)	-0.000129 (0.000115)	-0.0000253 (0.0000471)
Quadratic month trend	0.00000127* (0.000000613)	0.00000130* (0.000000596)	0.000000350 (0.000000259)	0.000000371 (0.000000304)	0.000000290 (0.000000279)	7.95e-08 (8.85e-08)
Observations	86905	86996	86905	86905	86905	86905

Standard errors in parentheses

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* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Overall results

