WHO IS BURNING MONEY AND THROWING IT IN THE AIR?: A QUANTITATIVE ANALYSIS OF DISPROPORTIONALITY OF TEXAS OIL AND GAS EXTRACTION FACILITY VENTING AND FLARING PRACTICES IN 2012

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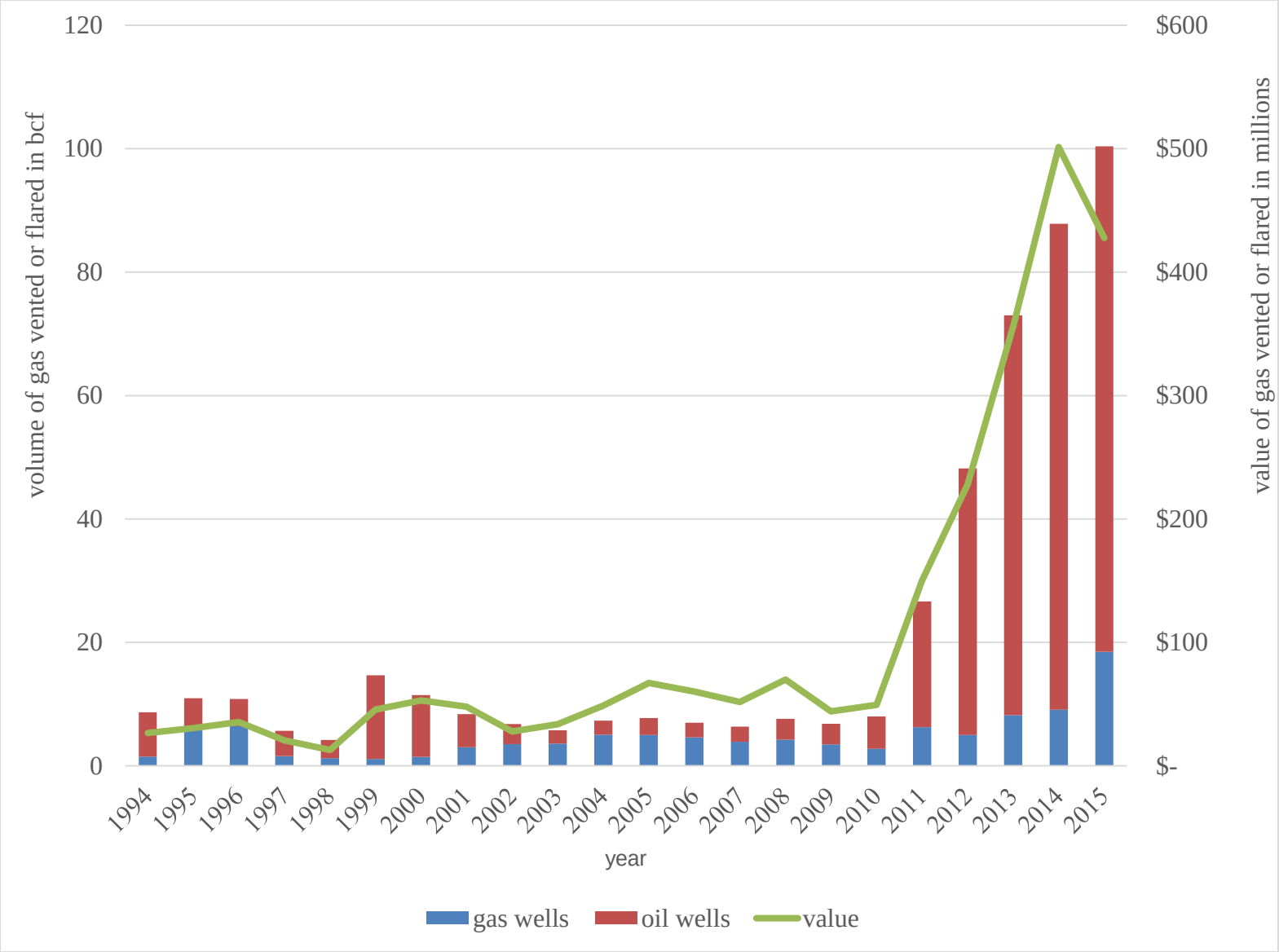
Oil and gas extraction industry venting and flaring

PROBLEMS PRODUCED BY VENTING AND FLARING

- **Produces greenhouse gas emissions**
  - Emits carbon dioxide
  - Largest source of methane emissions by the oil and gas extraction industry
- **Produces health hazards**
  - Largest industrial source of volatile organic compounds that cause increased hematological, breathing and skin problems to surrounding communities
- **Wastes a finite natural resource**

The Growing Problem of Venting and Flaring in Texas



Source: Texas Railroad Commission Production Data Query,
Energy Information Administration Natural Gas Prices

EXPLAINING EXTREMES

- **Disproportionality- Not all facilities pollute equally**
  - Most pollution is produced by a few high-risk polluters with privileged access to the environment (Freudenberg 2006)
- **Organizations are open systems**
  - The environmental behavior of industrial organizations is related to the characteristics of facilities, the companies that own them, and their surrounding political and institutional environment (Grant, Longhofer, and Jorgenson 2018)

QUANTITATIVE DISPROPORTIONALITY STUDIES

- **Chemical Production Plants**
  - Large facilities pollute more (Grant, Bergesen, and Jones 2002)
  - Subsidiaries pollute more (Grant and Jones 2003)
  - Facilities in socially vulnerable communities pollute more (Grant, Jones and Tratner 2004)
- **Electric Power Plants and/or Their Owning Firms**
  - Older facilities pollute more (Touche 2011)
  - Firms with more facilities pollute more (Prechel and Istvan 2016)
  - Firms with lower profits and more debt pollute more (Prechel and Zheng 2012)
  - Owning firms in states with fewer environmental regulations pollute more (Prechel and Zheng 2012)

GAP IN LITERATURE

- **Research has yet to explore disproportionality produced by the oil and gas extraction industry**
- **Why? Limitations of federal data!**
  - Oil and gas extraction industry is exempt from reporting to the Environmental Protection Agency (EPA) Toxic Release Agency (TRI)
  - Heavy polluting oil and gas extraction facility operators report to the EPA Greenhouse Gas Reporting Program (GHGRP) at the shale-level, not the facility-level

I overcome data limitations by using state records

RESEARCH GOALS

- **Research Question:** What types of facilities and operators are prone to extreme venting and flaring?
- **Objectives**
  - Visualize disproportionalities by mapping venting and flaring rates
  - Quantify the relationship between the characteristics of facilities and operators and facility venting and flaring practice engagement and magnitude
  - Quantify the relationship between the political context of facilities and facility venting and flaring practice engagement and magnitude

IMPORTANCE

- **Empirical Significance:**
  - Establishes methods to map venting and flaring volumes using state reports and identify the communities most affected
  - By identifying the types of facilities disproportionately responsible for venting and flaring most of the gas they produce, state regulators and decision makers can better target high-risk facilities and reduce most of the waste and pollution caused by venting and flaring
- **Theoretical Significance:**
  - Advances an open systems organizational theory approach to disproportionality
  - Establishes innovative two-part regression modeling methods to disproportionality

METHOD- HYPOTHESIS DEVELOPED USING OPEN SYSTEMS ORGANIZATIONAL THEORY

- **Economic costs relate to venting and flaring practices**
  - + Established Pipeline Far Away
  - + New Drilling
  - - Development Density
- **Organizational size relates to venting and flaring practices**
  - + Facility Oil Production Volume
  - + Facility Gas Production Volume
  - + Operator Oil Production Volume
  - + Operator Gas Production Volume
- **State regulation relates to venting and flaring practices**
  - + Permits
  - + Violations
- **Community embeddedness relates to venting and flaring practices**
  - + Minority Communities
  - - High Populated Communities
  - - High Income Communities

METHOD- DESIGN

- **Quantitative Cross Sectional Two-Part Hurdle Regression Analysis of All Producing Oil and Gas Extraction Facilities* in Texas in 2012 (N = 126,862 / N = 6,651), and the Companies Directly Responsible for Facility Operations (N = 4,608 / N = 455)**
- **Why Texas?**
  - Limited to single state in order to eliminate between-state variation in regulation and reporting of venting and flaring
  - Texas produces more than any other state
- **Why 2012?**
  - Year of heavy development in the middle of the recent shale oil boom

*** Facilities are considered the wells drilled on land within a single mineral lease+**

+ A mineral lease is a legal contract providing the operator with rights to drill for minerals on a plot of land

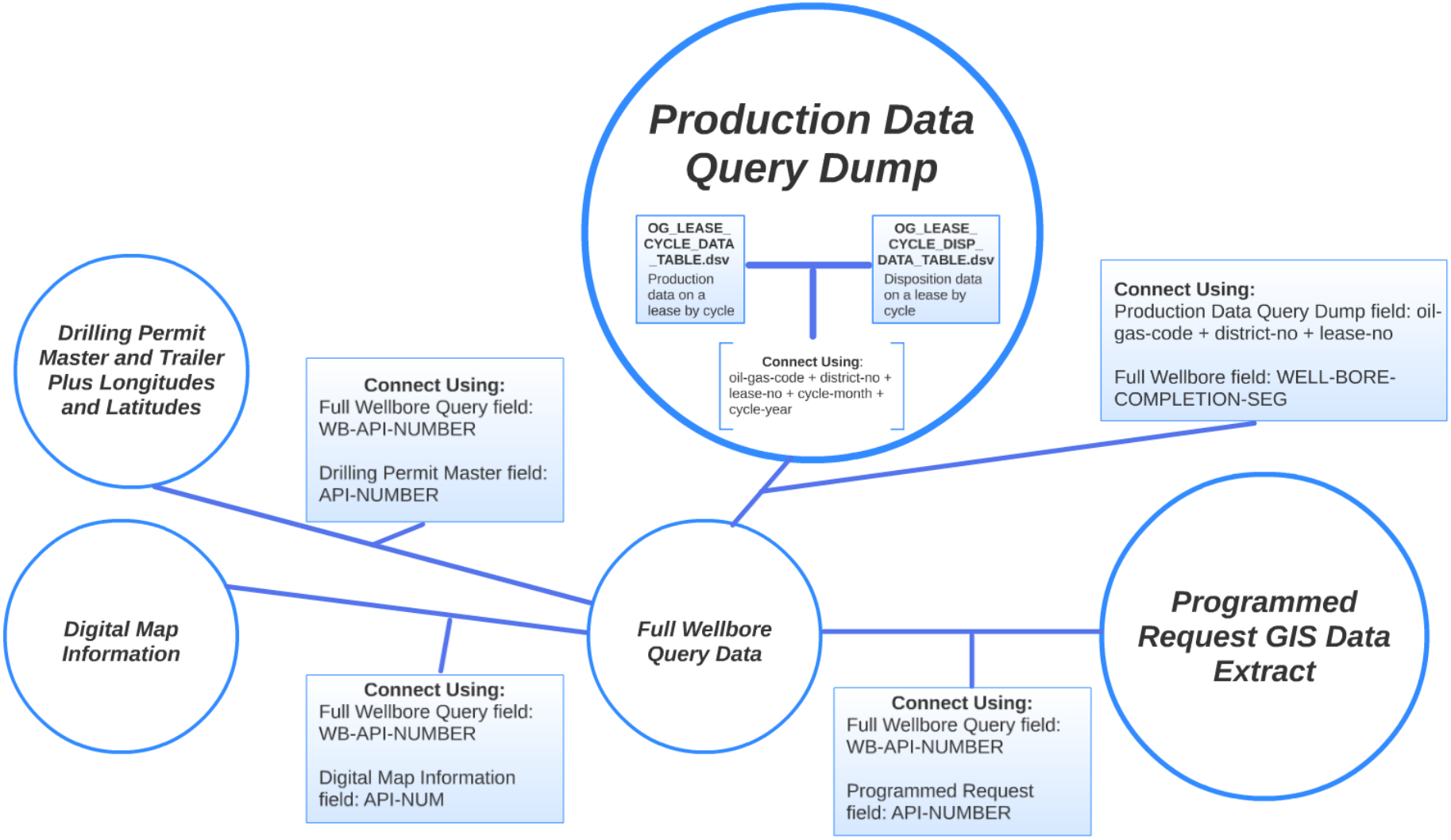
METHOD- DATA

- **Texas Railroad Commission Datasets**
  - Programmed Request Data Extract
  - Production Data Query Dump
  - Full Wellbore Query Data
  - Drilling Permit Master and Trailer Plus Longitudes and Latitudes
  - Digital Map Information
- **United States Energy Information Administration Natural Gas Pipeline Shapefile**
- **American Community Survey, Five-Year (2010-2014) Population Estimates, Geodatabase Format**

METHOD- MEASURES

	Variable	Measure	Source	Mean	Sd	Min	Max
Dependent Variables	Venting/Flaring Facility	1- Facility vented or flared 0-Not	TRC	.052	.222	0	1
	Venting/Flaring %	100 * Vented or flared / Produced	TRC	1.385	10.611	0	100
Economic Variables	Nearest Pipeline	Feet to nearest established gas pipeline	EIA	9,399	17,563	0	176,658
	New Drilling	1- New wells were drilled, 0-Not	TRC	.043	.203	0	1
	Development Density	Sqrt(number of wells within a mile)	TRC	4.611	4.721	0	1,403
Size Variables	Facility Oil Production	Sqrt(barrels of oil produced at facility)	TRC	32.027	65.946	0	3,256
	Facility Gas Production	Sqrt(mcf of gas produced at facility)	TRC	138.22	160.47	0	5,601
	Operator Oil Production	Sqrt(barrels of oil produced by operator)	TRC	1,045	1,294	0	6,532
	Operator Gas Production	Sqrt(mcf of gas produced by operator)	TRC	6,482	8,350	0	27,591
Regulation Variables	Permit	1- Received permit to vent or flare 0-Not	TRC	.004	.066	0	1
	Violations	Venting or flaring violations	TRC	.002	.068	0	9
Community Variables	% Black	Portion individuals living in block groups within a mile that are Non-Hispanic Black	ACS	4.211	7.436	0	88.075
	% Hispanic	Portion individuals living in block groups within a mile that are Hispanic	ACS	25.7	23.533	0	100
	Population Density	People per square mile in block groups within a mile	ACS	38.91	156.71	.007	6,707
	Economic Class	Median household income category of households in block groups within a mile	ACS	9.652	1.944	1	15

METHOD- DATA MANAGEMENT: CONNECTING RRC DATASETS



METHOD- DATA MANAGEMENT: CREATING THE GIS

1. Load all data tables into a geodatabase
2. Make X Y Event Layer using facility longitude/latitude coordinates
3. Project all shapefiles
4. Find nearest distance between facility points and established pipeline
5. Create a one mile buffer around facility points
6. Overlay facility buffers with American Community Survey block group shapefile
7. Match facility/block group data tables using unique identifier
8. Dissolve by facility/block group unique identifier

METHOD-
TWO-PART HURDLE REGRESSION

Part One: Logit Model Predicting Venting/Flaring Participation

$$\log\left(\frac{\varphi_{1j}}{1-\varphi 1_j}\right) = \gamma_0 + \sum_{k=1}^{K}\beta_k\left(M_{kj} - \overline{M_{kj}}\right) + e_j, \text{ where } e_{itj} \approx N(0,\sigma_e^2)$$

Where φ_{1j} denotes the probability that lease j vented or flared; γ_0 denotes the average log odds that a lease will vent or flare; β_k is the corresponding coefficient that represents the direction and strength of the explanatory variable (k is the number of variables at the lease-level); M_{kj} is the observation of the explanatory variable k for lease j, and $\overline{M_k}$ is the mean of the explanatory variable k; e_j represents the random error, which is assumed to be normally distributed with a mean of 0 and variance of σ_e^2.

Assumptions:

- Homoskedasticity
- Linearity of parameters
- Independent variables not strongly collinear

Huber's (1967) formula is used to produce consistent standard errors, even though the data is clustered by facility operator

METHOD-
TWO-PART HURDLE REGRESSION

Part Two: Negative Binomial Regression Model Predicting Venting/Flaring Magnitude

$$\mu_i = \exp(\ln(t_i) + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \ldots + \beta_k x_{ki})$$

$$\Pr(Y=y_i \mid \mu_i,\alpha) = \frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(y_i+1)} \left(\frac{1}{1+\alpha\mu_i}\right)^{\alpha^{-1}} \left(\frac{\alpha\mu_i}{1+\alpha\mu_i}\right)^{y_i}$$

Where , μ_i denotes the mean incidence rate of y per unit of exposure t (i.e., risk of new occurrence during period t). β_1 is the intercept. β_2, β_3, …, β_k are the estimated unknown regression parameters. Γ is a gamma noise variable which has a mean of 1 and a scale of v. α is 1 / v, and the model is estimated using maximum likelihood estimation techniques.

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- Linearity of parameters
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RESULTS- THE CODE AND MAP

https://tinyurl.com/vf12code

https://tinyurl.com/vf12map

RESULTS- MAP

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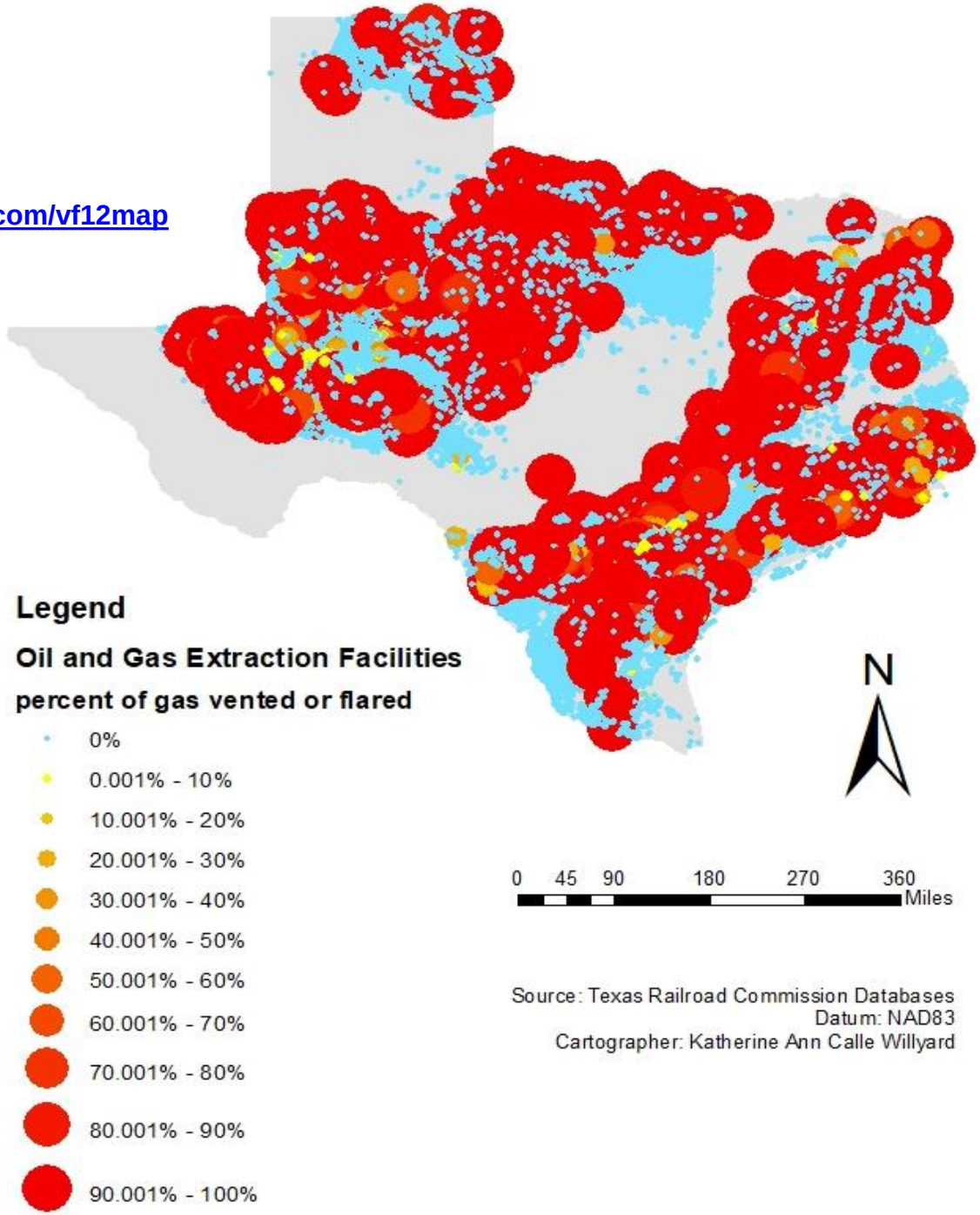

RESULTS- REGRESSION MODELS

	Variable	Hypothesized Relationship	Observed: Engagement	Magnitude
Economic Variables	Nearest Pipeline Distance	+	-	+
	New Drilling	+	+***	+*
	Development Density	-	-*	-***
Size Variables	Facility Oil Production	+	+**	+**
	Facility Gas Production	+	+*	-***
	Operator Oil Production	+	+***	+**
	Operator Gas Production	+	-	-***
Regulation Variables	Permit	+	+***	+***
	Violations	+	+***	+
Community Variables	% Black	+	-	+
	% Hispanic	+	+***	+
	Population Density	-	-	+
	Economic Class	-	+**	+

*** p<0.001 ** p<0.01 * p<0.05 (two-tailed significance tests)

FINDINGS

- **Venting and flaring practices are consistently associated with:**
  - **+ new drilling**
  - **- development density**
  - **+ facility oil production**
  - **+ operator oil production**
  - **+ permitting**
- **Findings suggest that economic incentives and legal opportunities to vent and flare are associated with extreme venting and flaring**

POLICY RECOMMENDATIONS

Federal

- **Implement Obama-Era "Flare Bans" on Federal Lands**

State

- **Revoke Texas Statewide Rule 32 Section f.2.D.**
- **Increase funding to the Texas Railroad Commission**
- **Increase accessibility of Texas Railroad Commission venting/flaring data**
- **Increase financial incentives for green investments**

QUESTIONS?

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