Note

June 4, 2024 Research update

1 Updates

- Presented 5/15 at CMU Doctoral Student Participatory Workshop on Climate and Energy Decision Making
- Presented 5/29 at AERE Summer Conference
- Working on estimating model
- Still no pipeline maintenance data
- Hiring an RA to work on 1) cleaning VIIRS flaring data, 2) empirical work on NM policy change, and 3) obtaining price futures data
- Working to develop project idea on energy infrastructure

2 Project overlap

Mark Agerton (assistant professor at UCSD) works in the oil and gas economics space. At AERE last week, he presented a project with significant overlap with ours. We spoke with him last year (April 2023) to hear about his work and tell him about our research plans. At that point, he shared a draft of his paper on midstream congestion. That version of the paper (dated April 2022) came to the conclusion that flaring and methane emissions are substitutes, due to increased emissions from gas transmission when gas is sold rather than flared. As such, they assert that increasing transmission congestion would have *decreased* emissions. Since these findings were in direct opposition to ours, we concluded that our project would be distinct enough to stand on its own.

The project that Mark presented last week had very different conclusions, but the same title, coauthors, and methods. Here's how it compares to ours:

- Similarities
  1. Find that midstream congestion is associated with increased flaring and emissions
  2. Use the Waha-Henry price gap as a measure of the pipeline capacity constraints (this is also something Agerton does in his 2020 review paper)
  3. Use pipeline notices and maintenance events data from Wood Mackenzie to instrument for pipeline congestion (we're still trying to get this data)
  4. Use Texas administrative data and VIIRS remote-sensed data to measure flaring activity
- Differences
  1. They look at processing capacity as well as pipeline congestion, linking processing plants with nearby wells
  2. They consider well-level production, but not new well drilling
  3. They do not have a theoretical model
  4. Their work does not disentangle the difference between the emissions impact of gas values vs. transmission costs
  5. They use TROPOMI satellite methane concentration estimates directly. We use a version of these estimates that has been filtered through an atmospheric inversion model to convert from methane concentrations to methane emissions.

One of Mark's coauthors saw me present a version of our paper last November. As per Ryan Kellogg's suggestion, I emailed Mark last week asking to speak. His response was lukewarm, saying that he wouldn't have time to talk but that they are planning to submit their paper soon. He also said that our model would allow us to "say something about the long run production response (which is probably the more relevant question than my short run stuff)."

3 Proposed empirical work on NM policy change

We've been working with a version of VIIRS flaring data cleaned by someone at EDF as part of a separate study on methane emissions estimation. This has limited the time frame and geographic granularity of some of our analyses. We have raw data and EDF's code to clean it, but haven't yet gotten around to cleaning the data ourselves. We are in the process of hiring an RA to do this, and thought that once we had the cleaned VIIRS data, it would be relatively simple to test the impact of New Mexico's recent changes in the regulation of flaring.

3.1 Background

In March 2021, New Mexico announced rules that would eliminate routine natural gas flaring by 2026. The rules called for operators to reduce flaring and venting starting May 2021, with the goal of achieving 98% capture by 2026. Flaring and venting is and will continue to be permitted in emergencies, but must be reported to state regulators.

Some media reports (including an article in The Guardian titled "Texas produces twice as much methane as better regulated neighbor, study finds") claim that these regulations have led to far lower emissions rates in New Mexico vs. Texas. However, differences in average emissions could easily be due to economic and geologic differences rather than regulations: the gas-oil ratio in the Texan Permian is much lower than that of the New Mexican Permian, meaning that Texan producers are less incentivized to capture the gas that they produce. Given the challenges of enforcing flaring regulation (especially with limited state budgets), it is not obvious that rules alone would reduce flaring. Any flaring reductions in recent years could also be atttributed to voluntary corporate commitments (by Exxon, Chevron, etc.) to curtail routine flaring in order to reduce emissions.

We would like to test the impact of New Mexico's rules using standard econometric techniques, comparing flaring in New Mexico to flaring in other states. As policymakers decide how best to reduce emissions from the oil and gas sector, it is important that we better understand how producers respond to regulation.

3.2 Methods

We plan to compare flaring and venting across Texas and New Mexico after these new rules took effect. We will focus in particular on the Delaware Basin, since this basin spans the border between Texas and New Mexico. We will use two types of data on flaring:

- **Producer-reported data:** In both Texas and New Mexico (and perhaps other oil and gas-producing states as well), producers must report flared and vented volumes to state regulators. In Texas, these reported volumes are included in monthly, producer-level disposition data made available by the Texas Railroad Commission. In New Mexico, the Oil Conservation Division collects these data. Since in both states, producers self-report flared and vented volumes, there are obvious concerns about data quality.
- **Satellite data:** As a check on producer-reported totals, we can also analyze data from the Visible Infrared Imaging Radiometer Suite (VIIRS) satellite instrument. VIIRS data can be converted into estimates of the number of flares and volume of gas flared each month. Although this methodology may not capture malfunctioning or unlit flares, due to its reliance on radiant heat and light, we believe that it can effectively capture trends over time.

There is potential to again collaborate with Daniel Varon (a post-doc at Harvard who has given us emissions data) on this project, in order to use his estimates of methane emissions for this period.

For all data sets, we plan to implement a regression discontinuity design. This approach will allow us to assess any changes in trend around the time of New Mexico's policy change. We will need to be careful about when we choose to be the policy start date: although New Mexico's rules weren't finalized until 2021, the state formed a Methane Advisory Panel in 2019 and draft rules circulated in July 2020.

4 Proposed new project on energy infrastructure

Emissions in Space: The Case of Manufacturing

For this project, I'd like to determine the endogeneity of industrial electricity demand across space in order to quantify tradeoffs between building new electric transmission lines vs. shifting demand to places with higher renewable potential. How much would either approach cost? How much emissions reductions can we get from both approaches?

It's helpful to think of a motivating example. Suppose production is split across two places:

A	**B**
Established industry hub	Little existing industry
More productive	Less productive
Better market access → lower trade costs	More remote → higher trade costs
Dirtier energy mix	Cleaner energy mix

Should a social planner who wants to reduce emissions from industry invest in

1. Transmission lines to bring cleaner electricity to place A,
2. Roads/rail to increase production in place B, or
3. Subsidies to increase production in place B?

I'm still working out the details of a model that I could use to answer these questions (see appendix if interested). Simultaneously, I'm pushing forward on getting access to Census of Manufactures data on plant-level energy use. I already have access to the equivalent data for India, but have some concerns about learning enough about the institutional context to have confidence in my work.

In either context, I would want the empirics to a) establish patterns in electricity and energy use across space and industries, b) calculate the parameters of the firm location decision, and c) calculate the (industry-specific?) elasticity of substitution between electricity and other energy.

5 Other ideas

- Methane extensions
  - *Industry consolidation*: Recently, there have been a lot of mergers in the pipeline and oil/gas production industries. What impact would we expect this to have on emissions? On the one hand, larger firms might be more conservative about expansion and are more accountable to shareholder pressure regarding expansion. On the other hand, larger firms are more likely to structure themselves in a way that can withstand lower oil prices going forward. Does consolidation represent a trade-off between short- vs. long-term emissions?
  - *Pipeline investment*: Is pipeline capacity over- or under-provided? How do investment decisions interact with both the social cost of methane leaks and government regulations capping rates of return? How do investment decisions interact with regulation concerning safety and leak monitoring (which is largely left to the companies themselves to conduct)?
  - *Landfill emissions*
- Other directions
  - *The hidden costs of adaptation infrastructure*: Adaptation infrastructure can have hidden costs linked with the residual risk that remains after these investments have been made (and after additional investments have been made in supposedly protected areas). One source of residual risk is insufficient maintenance. Even for federally funded construction, it's often up to localities to fund maintenance critical to upholding the promised level of protection. Principal-agent problems and locality credit constraints could reduce likelihood of maintenance costs being paid on time, generating residual risk. This risk might be more costly than baseline if it is not salient or if people can't adjust fast enough to changing risk profiles.
  - *Adaptation cost-sharing and ordeals*: Do local cost-sharing requirements and arduous application processes help or hinder the targeting of climate resilience funds towards the communities most in need? The optimality of these requirements depends on how accurately the government can assess social value of potential projects, as well as the correlation between locality ability to pay and project social value. Use data on grant applications and local characteristics to assess.

- *The cost of rushing regulation*: Under the Congressional Review Act, federal regulation is vulnerable to being overturned by Congress in the months after a federal agency finalizes a rule. Because the president can veto any attempted rollback, this means that in the last year of a presidential term, there's a huge incentive to get rules finalized early, so that it's harder for the next administration to reverse them. What are the costs of this rush to finalize rules? Compare rules finalized during the first half of an election year to rules finalized other times. Use ML tools to gauge "quality": typos? Detail? Specificity?
- *Increasing electricity demand by crypto and data centers*

6 Appendix

For "Emissions in Space", a model that captures the key dynamics of the problem could look something like the following (roughly following Redding 2022):

- Locations indexed by $n \in N$, each with an exogenous supply of floor space H_n
- **Labor**
  - $\bar{L}$ mass of workers, each supplying 1 unit of labor inelastically
  - Workers are perfectly mobile $\rightarrow$ amenity-adjusted real wages equalized across place in eq'm
- **Consumption**
  - Workers derive utility from goods consumption, amenities, and floor space. In place n, utility is:

$$U_n = \frac{B_n \nu_n}{P_n^{\alpha} Q_n^{1-\alpha}}, \quad 0 < \alpha < 1$$

    for amenities B_n, worker income ν_n, consumption goods price index P_n, price of floor space Q_n
  - Consumption price index for place n is a CES aggregation of varieties produced in all locations:

$$P_n = \left[\sum_{i \in N} \int_0^{M_i} p_{ni}(\psi)^{1-\sigma} d\psi \right]^{\frac{1}{1-\sigma}},$$

- **Production**
  - Monopolistically competitive firms produce varieties of the single good
  - Production combines labor and capital with energy (both fossil fuels and electricity):

$$Y = A_j \left[\pi_L L_j^{\rho_L} + (1 - \pi_L) X_j^{\rho_L} \right]^{\phi/\rho_L}$$
$$X_j = \Delta_j (\pi_F F_j^{\rho_F} + (1 - \pi_F) E_j^{\rho_F})^{1/\rho_F}$$

    for labor L_j, energy X_j, fossil fuels F_j, and electricity E_j.
  - Before entering, firms draw production tech: TFP A_i, energy productivity Δ_i, subst. elast. b/w labor and energy $\sigma_L = 1/(1 - \rho_L)$, subst. elast. b/w fossil fuels and electricity $\sigma_F = 1/(1 - \rho_F)$
  - Upon entering, firms choose production location to max. profits
  - Input costs vary by place: wages are set by market, fossil fuel and electricity prices depend on transport/transmission infrastructure and exogenous place component
- **Emissions**
  - Emissions from production derive from 1) fossil fuel use, and 2) electricity consumption
    - Fossil fuel emissions are assumed to be a constant multiple of fossil fuel consumption
    - Electricity consumption has a place-specific emissions factor
  - Emissions from transportation are a function of distance traveled