Regulating Greenhouse Gases from Coal Power Plants Under the Clean Air Act

Joshua Linn (RFF)
Dallas Burtraw (RFF)
Erin Mastrangelo (Maryland)

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Background: Efficiency at Existing Coal Plants

- EPA regulation of CO_2 emissions
  - Following 2007 Supreme Court decision, EPA has begun regulating CO_2 emissions
  - Performance/efficiency standards play central role
  - Already enacted: fuel economy standards for cars and trucks, standards for major new/modified sources
  - Regulation of existing fossil fuel electricity generators already underway; apparent focus on efficiency

- How costly and how effective are efficiency standards likely to be?
  - Many assessments of energy efficiency suggest very low costs, whereas others are less optimistic
  - What opportunities exist—what has already been adopted?
  - How big is the rebound effect?

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Operating Performance of Existing Coal Units

- Anticipating regulations for existing coal units
  - Coal accounts for about 1/3 of U.S. GHG emissions (EIA)
  - Based on engineering estimates, expect 2-5 percent efficiency improvements
  - Corresponds to 1.6 percent total GHG emissions, or 10 percent of the U.S.' 2020 target

- Costs of alternative policy designs
  - Putting aside legal issues, there are many ways to reduce emissions rates from existing coal units
  - Prominent examples: emissions cap, tradable emissions rate standard, inflexible emissions rate standard
  - Each policy provides different incentives for efficiency investments and operations
  - We could estimate costs by simulating a model of coal unit behavior

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Our Objectives

- Use observational data to analyze coal unit behavior
  - Construct a panel data set of coal unit operation and characteristics, 1985-2009
  - Merge in coal prices and other market and regulatory variables
  - Assess abatement opportunities based on operating efficiency (heat rates)
  - Estimate costs of reducing emissions using coal prices and heat rates
  - Estimate rebound effect

- Compare cost effectiveness of alternative policies
  - Use empirical estimates as inputs in a simple model of the electricity sector
  - Compare cost effectiveness of alternative policies: emissions tax and performance standard (flexible and inflexible)
  - This part is still to come…

Data

- Sources:
  - EIA 767: by boiler/generator, monthly heat input and generation, boiler vintage, firing type, and other characteristics
  - EIA 860/861: plant ownership and generator characteristics
  - EIA 423: coal prices by plant and year

- Summary:
  - Data are aggregated to boiler/generator unit
  - Final data set includes nearly all coal generators: 1250 units and 340 GW total capacity in 2008 (includes 97% of 2008 emissions)

Heterogeneity

- Annual heat input vs. average heat rate for a single year
  - Units with lower heat input tend to have higher heat rates
  - Lots of heat rate variation

- Distribution by firing type
  - Distributions vary a lot by firing type
  - Implication: some heterogeneity reflects technological differences
  - Not all heterogeneity implies abatement opportunities

Figure 1: Heat Input vs. Heat Rate (2008)

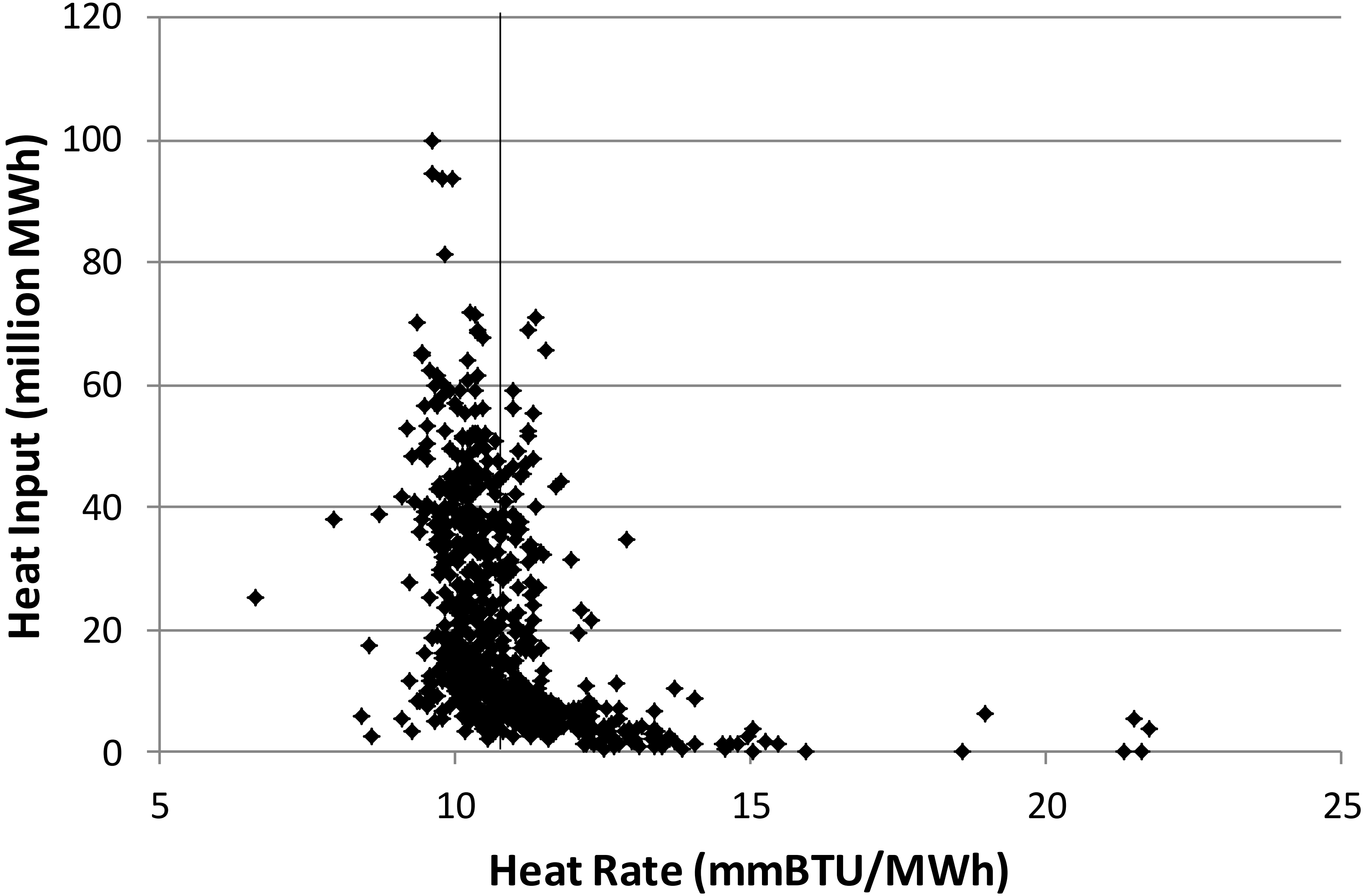
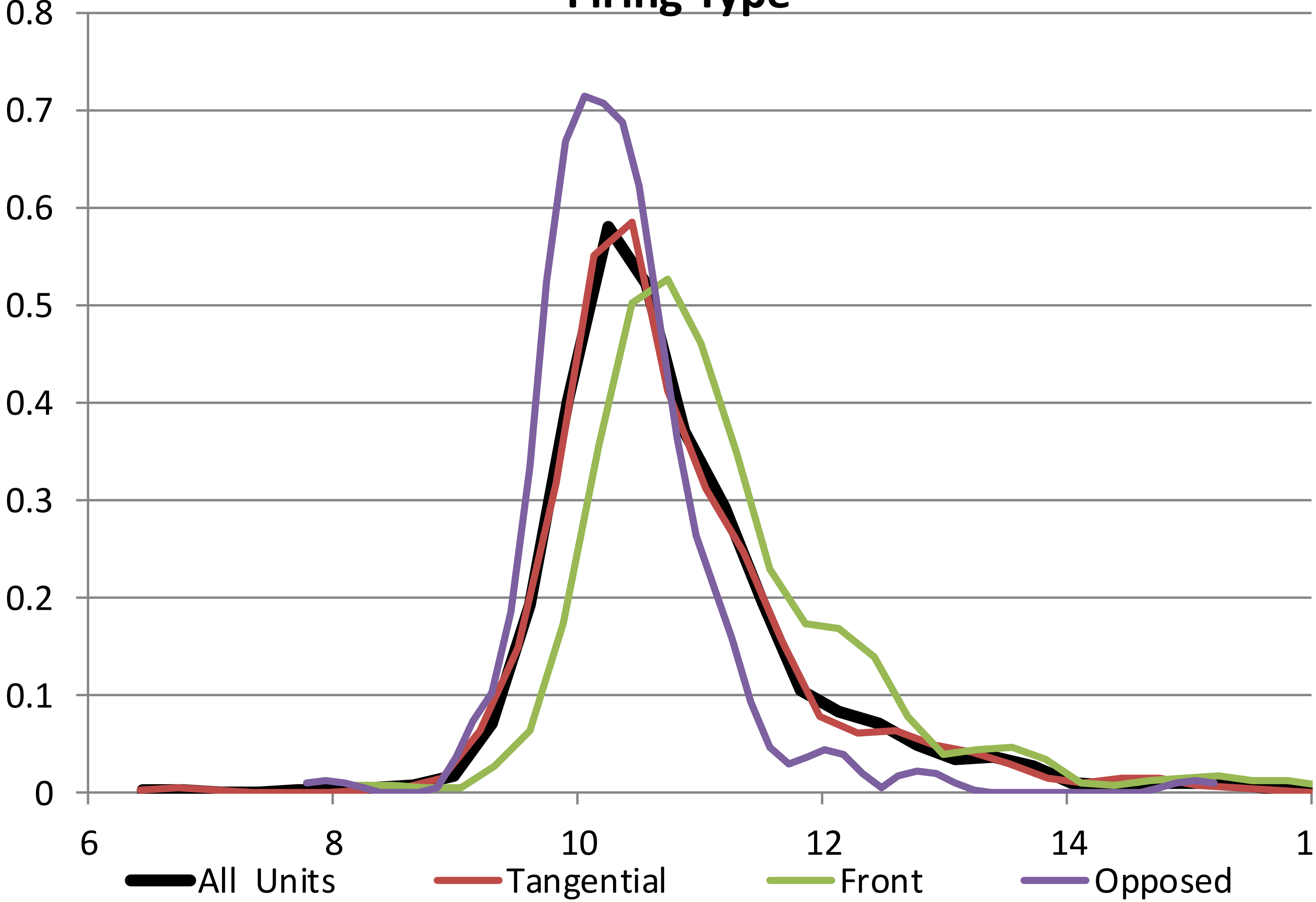


Figure 2: Estimated Heat Rate Distribution by Firing Type



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Framework for Estimating Abatement Costs and Assessing Policies

- Comparing cost effectiveness across policies
  - Using a model of coal unit behavior, we'll simulate effects of different policies
  - We'll use coal prices as a proxy for the incentives a policy creates to change heat rates and utilization
  - Eventually, compare emissions tax, tradable emissions rate standard, inflexible standard, and the effect on heat rate and utilization.

- How do policies affect emissions?
  - Policies create incentives for firms to change heat rates and utilization
  - Example: carbon-based tax on coal raises fuel costs, which creates incentives to reduce heat rate and utilization
  - Example: tradable performance standard introduces a shadow price on heat rate proportional to fuel costs; expect greater utilization than with a tax

Estimation, Interpretation, and Identification

- How do coal prices affect heat rates?
  - Estimate simple linear regression of log heat rate on log coal price:

$$lnHR_{it} = \alpha lnP_{it} + X_{it}\beta + \epsilon_{it}$$

  - Interpret α as elasticity of heat rate to coal price
  - Expect α to be negative because high coal prices raise the benefit of improving efficiency

- Addressing the major identification concerns
  - 1) Potentially spurious results: coal prices affect utilization which affects heat rates
    - Aggregate to five-year time intervals and control for utilization
  - 2) Unobserved unit, plant or firm characteristics correlated with coal prices

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Main Estimation Results

Effect of Coal Prices on Heat Rates

	Dependent Variable: Log Heat Rate			
	(1)	(2)	(3)	(4)
Log Coal Price (α)	-0.053 (0.008)	-0.046 (0.008)	-0.018 (0.009)	-0.013 (0.009)
Number of Observations	4,927	3,908	4,927	3,908
R-Squared	0.75	0.77	0.93	0.94
Specification	Baseline	Add state economic controls to (1)	Add unit fixed effects to (1)	Add firm X year fixed effects to (3)

Other control variables: age, size, firing type, fuel type, cogenerator, scrubber, SCR, utilization, state, time period, ownership type

Implications and Future Work

- Abatement opportunities and costs
  - Maximum technically feasible abatement under alternative hypothetical emissions rate standards: 5-6 percent
  - Parameter estimate implies that a $10/ton CO_2 tax on coal would reduce heat rates by 1-2 percent
  - Somewhat more abatement than engineering estimates suggest
  - Large rebound effect: elasticity of utilization to coal price -0.2 to -0.4

- Open questions
  - Suggestive evidence that NSR affects heat rates
  - Compare cost effectiveness of different policies by estimating their effects on heat rates and utilization:
    - Emissions tax
    - Tradable emissions rate standard
    - Inflexible emissions rate standard