Regulating Power Plant Emissions:
Environmental Justice, Enforcement, and Regulator Priorities

Since 1994, following an executive order by President Clinton, the Environmental Protection Agency (EPA) has been mandated to take environmental justice considerations into account in its decision-making. Despite this long-standing mandate, disadvantaged groups in the U.S. continue to be disproportionately exposed to pollution (Banzhaf, Ma, and Timmins, 2019), which may be leading to their lower life expectancy and worse health outcomes (Arias, Heron, and Xu, 2017; Deryugina et al., 2019). Further, studies have suggested that regulators may enforce pollution regulations less in neighborhoods with a high proportion of minorities (Shadbegian and Gray, 2012). Therefore pollution disparities may be due in part to unequal enforcement of regulations.

In this project we will analyze the enforcement of air pollution regulations at fossil fuel power plants and how this enforcement varies across the demographic groups exposed to each plant's emissions. Electricity generation is critically important to society but emits substantial local pollutants that harm human health, with damages for the U.S. estimated at $57.3 billion in 2017 (Holland et al., 2020). Moreover, the distribution of the damages from local air pollution disproportionately fall on minority and lower income groups (Fowlie, Walker, and Wooley, 2020), implying that the externalities from electricity generation lead to substantial equity concerns. The fact that these environmental disparities persist despite the long-standing executive order suggests that a better understanding of how the EPA and other enforcement agencies use environmental justice in their decision-making is overdue. Finally, the new Biden administration has committed to a renewed focus on issues of environmental justice (Mulholland and Brave NoiseCat, 2020). Together, these facts emphasize the timeliness and policy-relevance of this research agenda.

In particular, we seek to answer two main research questions. First, we will measure the extent to which regulators are basing their enforcement decisions on environmental justice considerations in practice. Second, we propose to model how changing this focus on environmental justice would affect environmental disparities.

To understand how the EPA bases its regulatory enforcement on environmental justice concerns, we propose to model regulator preferences. Regulators may value pollution reductions but also the cost to local facilities in terms of fines. Since we cannot directly observe the regulators' relative weights on fines and pollution, a structural model that estimates these preferences from regulators' decisions is important. In particular, this model will allow us to answer policy-relevant questions: What is the "cost" to the EPA of imposing fines on plants relative to the damages communities face from pollution? How do these relative costs vary based on the demographics of the affected neighborhoods and the characteristics of the regulator?

Our model incorporates the specifics of pollution regulation in the electricity sector. Electricity generation in the U.S. is subject to the Clean Air and Water Acts which regulate pollution discharges from power plants. Federal, regional, and state agencies enforce these laws with systems of inspections and penalties. Regulators use substantial discretion in their enforcement decisions (Kang and Silveira, 2021), which makes quantifying the extent and impact of environmental justice considerations difficult. Our previous work (Blundell, Gowrisankaran, and Langer, 2020, henceforth BGL) has shown that enforcement of the Clean Air Act is dynamic, with repeat offenders being punished more severely than first-time violators but did not seek to estimate the tradeoffs faced by regulators. To understand regulator priorities, we propose to model the dynamic, strategic interplay between regulators and firms for the electricity sector. This structural model will allow us to estimate the extent to which regulators tailor their enforcement strategies to the demographics of each

neighborhood, thereby measuring how much environmental justice enters regulator decision-making. Ultimately, we will use our estimated model to evaluate how changing regulator incentives would affect pollution exposure in minority neighborhoods.

Existing Literature

Our proposal contributes to filling knowledge gaps in three broad areas. First, we seek to determine the extent to which environmental enforcement is an underlying cause of environmental disparities. There is a substantial literature that documents environmental disparities by demographic group, e.g. Fowlie, Holland, and Mansur (2012), Grainger and Ruangmas (2018), Colmer et al. (2020), Currie, Voorheis, and Walker (2020), Hernandez-Cortes and Meng (2020), and Deschenes and Weber (2021). However, this literature generally does not consider the underlying causes of these disparities. We directly estimate the preferences of environmental regulators and use these preference estimates to understand the extent to which current regulatory enforcement is causing environmental disparities and how alternative regulatory priorities might affect environmental justice outcomes.

Second, our estimation of regulators' priorities will extend the literature that investigates differences in environmental enforcement. This literature includes Magat and Viscusi (1990), Shimshack and Ward (2008), Keohane, Mansur, Voynov (2009) and BGL among others. While this literature has examined how polluters respond to environmental enforcement, little is known about the underlying tradeoffs that regulators confront in their decision-making. Moreover, this literature has not considered whether regulators follow the Clinton executive order and consider environmental justice in enforcement.

Third, we extend the literature that takes theoretical models of enforcement to data by considering issues surrounding environmental justice. Earlier works in this area include Agarwal et al. (2014), Duflo et al. (2018), and Kang and Silveira (2018). We build on this literature by combining environmental justice questions with a structural empirical model that allows us to simulate outcomes under counterfactual regulator priorities.

Data

Our analysis will use five main datasets. First, we propose to use the EPA's Continuous Emissions Monitoring System (CEMS) data on monthly emissions of criteria and toxic air pollutants. Second, we propose to use the EPA's Environmental Compliance History Online (ECHO) data---as described in BGL---to understand regulatory enforcement. Third, we will merge data on pollution abatement investment decisions from the EIA form 860. Specifically, we propose to use the information on pollution control technologies at the boiler level to understand when facilities make investments in pollution abatement. Fourth, we will merge in data on marginal pollution damages by county and pollutant from AP3. Finally, we use demographic data from the American Community Survey.

Empirical Approach

As modeled in BGL, enforcement of the Clean Air Act incorporates substantial dynamics, where repeat violators are subject to greater scrutiny and penalties. BGL modeled plants' decisions regarding investments in pollution abatement when faced with a dynamic enforcement policy, considering electricity generation and other high-polluting sectors. BGL showed that dynamic enforcement allows the regulator to achieve the same level of pollution with substantially lower fines than it would otherwise require. However, it did not directly consider the factors regulators consider in their enforcement decisions.

We propose to estimate environmental regulators' objective functions in their enforcement decisions for power plants. Building on our existing work, we will develop and estimate models of regulatory preferences over fines, other regulatory actions, plant

investment costs, and the distribution of pollution across communities, in a dynamic enforcement setting. Our model allows regulators to value enforcement activities and pollution differentially based on the income and race of the people affected and the characteristics of the regulator. Ultimately, we will evaluate how Clean Air Act enforcement decisions affect the welfare of minority and low-income communities and how alternative preferences would impact these outcomes.

We model each power plant playing a dynamic game with a regulator. We specify a Markov Perfect equilibrium, where the regulator makes optimal state-contingent decisions rather than precommitting to these decisions. We model regulators' objective functions in order to understand the extent to which regulators value environmental justice concerns. In particular, regulators seek to minimize the weighted sum of plant costs and damages from pollution. We allow regulators to weight these two elements differently across geographic areas, depending on the EPA region or state and the demographic characteristics of the areas in which the plants are located and in which pollution damages would occur. In particular, we will consider whether regulators' preferences are dependent upon the race and income of neighborhood residents.

Pollution damages occur stochastically. Plants detect them concurrently with the regulator through monitoring systems and inspections. Plants that pollute more than the legal limits are placed in different levels of violator status, depending on their excess amounts of pollution. Plants make optimizing decisions about whether to invest in damage remediation through the installation of new abatement devices. These investments take time and are not always successful in lowering damages. We allow for an escalation mechanism with dynamic enforcement, as is present in the data, whereby plants in higher levels of violator status are punished more severely for the same violations as plants in a lower violator status. We also allow for heterogeneous plants and an inability to contract on plant type.

Each period corresponds to a year and the future is discounted with a common discount factor. Each period, the regulator first receives an i.i.d. private information shock to the value of an inspection and then decides whether or not to inspect the plant. The regulator and plant then receive a signal, which provides information on the presence and severity of Clean Air Act Amendments' compliance issues, including emissions from multiple pollutants. The signal precision is a function of whether the plant was inspected. Following the regulator action, the plant, if a violator, makes decisions regarding whether or not to invest in pollution abatement. We model investment as a change in abatement equipment for NO_X, SO_2, or mercury, as these are the three pollutants for which the Energy Information Administration tracks abatement technologies. A plant chooses its investment decisions in order to minimize its expected discounted sum of the costs from inspections, violations, fines, and investment. A plant that invests incurs costs from its investments, but increases the chance that it transitions to a lower violator status in future periods. The regulator chooses its inspection and fine policies to minimize the expected weighted sum of damages from pollution, and plants' costs of investment, fines, and regulatory compliance.

We propose to estimate plants' costs of investing in pollution mitigation technologies using methods similar to BGL. Specifically, we will first estimate conditional choice probabilities (CCPs) for the regulator. We will then solve for the dynamic investment decisions of plants faced with these CCPs in order to recover the parameters on the relative costs of investment in pollution mitigation compared to the costs of fines, inspections, and investments across parameter vectors. We will allow for heterogeneity in plant costs with a random coefficients framework similar to BGL. This estimation seeks to match investment decisions, as predicted by the model, to investment decisions in the data. In contrast to BGL, we will take advantage of more specific measures of investment—that are only available for power plants—in estimating their cost functions. Specifically, our measures of investment

will be the pollution abatement technologies available to power plants and our measure of violator status will be continuous, reflecting the extra emissions reported by power plants' continuous emissions monitoring systems.

Following our estimation of plant costs, we will estimate regulators' relative weights placed on pollution damages and plants costs, which vary across EPA regions, states, and demographic characteristics. This estimation seeks to match state-contingent fines and inspection rates. Since regulators solve a dynamic decision problem, we will use the estimated policy rules for plants to recover regulators' preferences. This is similar to our estimation of plants' costs.

Identification of plants' costs in our model follow from very similar arguments to those discussed in BGL. Specifically, identification of plant costs stem from differences in responses of plants across different regulatory environments and across different violator statuses within a regulatory environment. We identify regulators' preferences from the policies that regulators choose. Essentially, regulators can choose from some continuum of fine and pollution policies, where higher fines imply lower pollution. The marginal tradeoffs between these variables depend on plant optimization. By observing combinations of pollution and fines that different regulators choose, we can infer the extent to which regulators value pollution and plants' costs differently, based on EPA regions, states, and demographic characteristics.