ANNUAL REVIEWS

Annual Review of Resource Economics

Environmental Justice: Establishing Causal Relationships

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Annu. Rev. Resour. Econ. 2019. 11:377–98

First published as a Review in Advance on April 12, 2019

The *Annual Review of Resource Economics* is online at resource.annualreviews.org

https://doi.org/10.1146/annurev-resource-100518-094131

JEL codes: D63, J15, Q53, Q58

Keywords

environmental justice, inequality, discrimination, distributional analysis, gentrification

Abstract

The environmental justice literature has found that the poor and people of color are disproportionately exposed to pollution. This literature has sparked a broad activist movement and several policy reforms in the United States and internationally. In this article, we review the literature documenting correlations between pollution and demographics and the history of the related movement, focusing on the United States. We then turn to the potential causal mechanisms behind the observed correlations. Given its focus on causal econometric models, we argue that economics has a comparative advantage in evaluating these mechanisms. We consider (*a*) profit-maximizing decisions by firms, (*b*) Tiebout-like utility-maximizing decisions by households in the presence of income disparities, (*c*) Coasean negotiations between both sides, (*d*) political economy explanations and governmental failures, and (*e*) intergenerational transmission of poverty. Proper identification of the causal mechanisms underlying observed disproportionate exposures is critical to the design of effective policy to remedy them.

1. INTRODUCTION

Over 30 years of research has documented that poor and/or minority populations face disproportionate exposures to environmental pollution. This finding has given rise to an environmental justice movement seeking to address such inequities. What is environmental justice? The US Environmental Protection Agency (EPA 2018) defines it as

> …the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no population, due to policy or economic disempowerment, is forced to bear a disproportionate share of the negative human health or environmental impacts of pollution or environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies.

While the EPA's definition addresses disparate impacts and decision-making processes, other working definitions place more emphasis on the mechanisms that lead to inequitable exposure. For example, consider the definition contained in the 2001 Declaration of Principles, established by the Brazilian Network for Environmental Justice:

> We understand environmental injustice to be those social and economic mechanisms which unequal societies use in order to channel the lion's share of the environmental damage caused by development towards low-income populations, discriminated groups, traditional ethnic groups, working class neighborhoods and, in general, towards marginalized and vulnerable populations. (Herculano & Pacheco 2008, p. 256)

As this definition highlights, understanding the socioeconomic mechanisms behind the observed correlations is crucial for characterizing the nature of the injustice and for understanding the efficacy of any policy solutions (Been 1993, 1994; Blais 1996; Foster 1998; Pulido 2000; Banzhaf 2012).

A number of broader reviews of the environmental justice literature already exist.[1] In a previous piece for the *Annual Review of Environment and Resources*, Mohai et al. (2009) summarized the environmental justice literature beginning with protests over the siting of a landfill in Warren County, North Carolina, which were followed by early exposure studies, the ensuing debates about race versus class and alternative exposure metrics, and then a discussion of the mechanisms behind these disparate exposures.

This review approaches environmental justice from the perspective of economics, emphasizing in particular the insights economics can offer into causal mechanisms. Although the field of environmental justice is interdisciplinary, drawing on insights from sociology, law, political science, human geography, medicine, and other fields, economics may be particularly valuable when it comes to understanding such mechanisms. At its core, economics is about decision making under constraints. Applied to producers, this gives us the tools to ask why a firm chooses to locate a noxious facility in a particular neighborhood. Is the siting decision motivated by simple cost-minimization concerns? Do those cost-minimization concerns incorporate the perceived costs of dealing with local community groups who might object to the facility's siting? Looking at the other side of the market, what motivates a household to choose to live in a particular neighborhood? How does the household trade pollution exposure for the opportunity to consume other necessities of life? How do constraints (income, employment, information, and so forth) affect

[1] Examples include Mohai & Bryant (1992), Brown (1995), Szasz & Meuser (1997), Evans & Kantrowitz (2002), Bowen (2002), Ringquist (2005), Noonan (2008), and Banzhaf et al. (2018b). Book-length introductions include Bullard (1994), Cole & Foster (2001), and Holifield et al. (2017).

those decisions? Beyond theory, innovations in empirical design can help assess which of the stories carry the most weight. Well-intentioned policies made with a poor understanding of these processes may set in motion unanticipated consequences.

This review proceeds as follows. Section 2 briefly reviews the history of the environmental justice movement, followed by Section 3, which provides a short summary of the research documenting disproportionate exposure. Section 4, the heart of our review, considers the mechanisms that may yield inequitable exposure to pollution and assesses the empirical evidence supporting or contradicting those hypotheses. Section 5 discusses policy incidence, including the costs of policies that address environmental inequities. Section 6 concludes.

2. HISTORY OF THE ENVIRONMENTAL JUSTICE MOVEMENT

Many attribute the birth of the environmental justice movement to the Warren County protests in North Carolina in 1982 (Hampson 2010). The state had decided to place 31,000 gallons of illegally dumped polychlorinated biphenyl (PCB)-contaminated soil in a private landfill site in Warren County, a predominantly black and low-income community, over an alternative location in Chatham County, even though the site in Warren County had a shallow water table that posed risks to drinking water quality for nearby residents. Residents soon protested the siting of the PCB landfill, which drew widespread support from civil rights groups and gained national media attention.

Events in Warren County sparked interest among academics and policy makers. First, through a technique of narratives and case studies, scholars came to point out that events like Warren County were not isolated (e.g., Bullard 1994). In a call for more systematic evidence, US Representative Walter Fauntroy requested a report from the US General Accounting Office (GAO), which resulted in the GAO (1983) investigation of racial composition around four major landfills located in the south. It found that three of the four communities examined were majority African American (over 50%) compared to a much lower share of African Americans at the state level (22–30%). Bullard (1983), in a study looking at the placement of incinerators and landfills in Houston, Texas, found that about half of the facilities were sited in predominantly black communities, even though blacks accounted for only 25% of Houston's population. Following the GAO and Bullard studies, the United Church of Christ (UCC) commissioned the first national analysis of disparate impacts by race (UCC 1987). Among other findings, it found evidence that there were twice as many people of color, on average, in zip codes with a commercial hazardous waste facility.

In 1992, the EPA compiled a report surveying the evidence (EPA 1992). Although large gaps in the data existed, the report found enough convincing evidence that "racial minority and low-income populations experience higher than average exposures to selected air pollutants, hazardous waste facilities, contaminated fish and agricultural pesticides in the workplace." In the same year, the Office of Environmental Equity, later renamed the Office of Environmental Justice, was created. In 1994, President Clinton issued Executive Order 12898, directing all agencies to consider the consequences on minority and low-income populations in all rulemaking and to devise strategies for implementing environmental justice. The order still stands.

3. DOCUMENTING INEQUITIES

A large literature has documented the socio-demographic characteristics of communities that experience environmental nuisances. Virtually all studies have consistently confirmed the first-order finding of simple correlations between pollution exposure and both race and income. However, there is less consensus about each of these correlations after conditioning on the other or after conditioning on other factors, as through multivariate regression. Finding that race matters even after controlling for income or vice versa may have important implications for understanding causal mechanisms, an issue we return to in Section 4.

There may be several reasons why findings using multiple regression are inconsistent (Ringquist 2005, Mohai et al. 2009). Here, we highlight one of these issues: the type of pollution studied.[2] Environmental justice studies have considered a variety of pollution types and sources. The early literature typically considered exposure to TSDFs (treatment, storage, and disposal facilities). Studies that found evidence of correlation with race include those by Ringquist (1997), Hird & Reese (1998) and Sadd et al. (1999). A number of studies have taken different methodological approaches to the measurement of disparate impacts. Burby & Strong (1997) conducted interviews and analyzed pollution perceptions by race and socioeconomic status. Baden & Coursey (2002) integrated detailed demographic history with a focus on a particular city. Davidson & Anderton (2000) consider a broader set of facilities governed by the Resource Conservation and Recovery Act (RCRA) rather than just TSDFs, finding evidence of higher exposure in working class neighborhoods with a lower percentage of minorities. Atlas (2002) did not find evidence of racial inequities looking at companies that manage their own hazardous waste (as opposed to commercial hazardous waste companies).

After this initial focus on undesirable land uses, a second generation of studies has looked specifically to air and water releases, such as from the toxic release inventory (TRI), often using toxicity weights to aggregate pollutants.[3] Others have considered measures of ambient concentrations instead of emissions. Clark et al. (2017) and Rosofsky et al. (2018) examine disparate impacts in criteria pollutants (i.e., NO_2 and $PM_{2.5}$). Liévanos (2017) found evidence of racial inequities in exposure to toxic hazards released in surface water.

Explicitly modeling the linkage between emissions and concentrations, Chakraborty & Armstrong (1997) use a geographic plume analysis based on a TRI pollution dispersion model of Des Moines, Iowa and compare results with those of a circular buffer model. Using 1990 census data, they find more nonwhites to be residing in the pollution buffer based on the plume rather than a simple circle. Ash & Fetter (2004) similarly use an atmospheric dispersion model to explain 1998 toxicity-adjusted exposure to air pollution with 1990 census data, finding evidence that African Americans tend to reside in both more polluted cities and more polluted neighborhoods within those cities, while Hispanics tend to reside in less polluted cities but in more polluted places in those cities. Shapiro (2005) also uses a dispersion model for TRI pollution accounting for toxicity. He finds that capacity for collective action and ability to process complex information matters more than race in explaining changes in exposure to toxics.

Morello-Frosch & Jesdale (2006) use air exposure modeling to measure disproportionate exposure to lifetime cancer risk and find important correlations with race, even after controlling for other socioeconomic characteristics.[4] Collins et al. (2015) also use cancer risk estimates from hazardous air pollution exposure from road emissions in the Miami metropolitan area, finding that blacks and Hispanics face greater exposure, as do renters and those who express an interest in living closer to work and public transit.

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[2] Equally important is how the relevant population exposed to that pollution is defined—in particular, is it based on shared spatial units (i.e., unit hazard coincidence) or distance-based buffers. In addition, the choice of large geographic units can lead to the "ecological fallacy." For further discussion of these topics, we refer the reader to Mohai & Saha (2006), Baden et al. (2007), Mohai et al. (2009), and Banzhaf et al. (2018b).

[3] For example, Bowen et al. (1995), Kriesel et al. (1996), Brooks & Sethi (1997), Ringquist (1997), Arora & Cason (1999), Sadd et al. (1999), and Banzhaf & Walsh (2008).

[4] Others taking a similar approach include Apelberg et al. (2005), Pastor et al. (2005), Hun et al. (2009), Chakraborty (2012), and Depro et al. (2015).

Emphasizing the importance of cumulative impacts, other studies have analyzed the tendency for multiple nuisances to cluster in the same community, exploring concerns that harms might increase more than proportionally with increasing exposures. Morello-Frosch & Shenassa (2006) and Sadd et al. (2011) examine the role of place-based stressors that affect vulnerable communities and create adverse health impacts at lower pollution concentrations. Su et al. (2012) create an index of cumulative environmental hazards and use it to explore inequality, expanding the analysis to include heat stressors. Some scholars have referred to these areas as sacrifice zones (Lerner 2010), perhaps not only because of the multiple sources of insults, but also because of the sentiment that these areas have received unequal protection from policy makers or are targeted by corporations.

Chakraborty et al. (2011) provide a historical overview of the different methods used to model exposure to adverse health conditions, beginning with unit hazard coincidence and moving to a fixed buffer, pollutant transport and, finally, health risk from exposure.

Beyond the commonly used air and water metrics, other studies have looked at inequality in other metrics. Porter & Tarrant (2005) examine disparities in proximity to wilderness areas and outdoor recreation sites but fail to find strong correlations with race. In contrast, Wolch et al. (2005) find racial disparities in access to park space in Los Angeles, whereas Gerrish & Watkins (2017) find significant evidence for race and income disparities in a meta-analysis of urban tree cover. Casey et al. (2017) explore disparate impacts of noise pollution and find that it is highly correlated with segregation, regardless of racial composition. These varying types of risks from TSDFs to urban tree cover may elicit different behavioral responses and could account for some of the differences in conclusions across environmental justice studies.

4. MECHANISMS

Studies of disparate impacts, like those described in the previous section, ignore a number of policy-relevant distinctions regarding how inequitable exposure arises. We begin by describing two of the main economic forces at work in explaining the "why" behind environmental injustice: siting and sorting. Put simply, was pollution placed in disadvantaged neighborhoods, or was the siting process equitable but followed by population resorting that led to inequitable exposure? Putting the firm side and the household side together, theories of Coasean bargaining posit that observed patterns emerge from an equilibrium process of bargaining. Alternatively, environmental injustice could arise from inequitable application of enforcement resources by regulatory agencies or other sorts of government inaction or failure, which in turn may result from pressures from either the firm side or household side. A different explanation involves intergenerational dynamics, where certain groups start life at a disadvantage because of pollution exposure suffered in childhood. That disadvantage plays out in the form of budget constraints and increased pollution exposure in adulthood.

The answers to these questions dictate whether environmental injustice can simply be solved by zoning restrictions or some other sort of rulemaking or whether it is, at its core, a more complicated problem of income inequality.

4.1. Siting

Although the papers described in Section 3 analyzed contemporaneous correlations between pollution, race, and class, another important strand of the environmental justice literature focuses on siting and examines socio-demographics at the time at which nuisances were sited. Examples of such work include those by Been (1994), Oakes et al. (1996), Lambert & Boerner (1997), Been & Gupta (1997), Arora & Cason (1999), Baden & Coursey (2002), Morello-Frosch et al. (2002), Ash & Fetter (2004), and Saha & Mohai (2005). Been (1994) reexamines the study areas previously considered by US GAO (1983) and Bullard (1983) but instead focuses on the socio-demographics as of 1970, before many of the sites became operational. With respect to the GAO analysis, she finds that the percentage of African Americans in 1970 in host communities was 1.6 to 3.3 times higher than that of their corresponding state averages. Turning to Bullard (1983), she finds that four out of the ten sites had proportions of African Americans that were significantly greater than that, while approximately 25% of all Houston residents were black, providing modest evidence for disparate siting behavior.

Wolverton (2009) also evaluates socioeconomic conditions at the time of siting, paying particular attention to other local attributes that the firm might consider in its profit-maximization problem. She characterizes the siting process using a spatial choice model for the firms, explicitly accounting for substitute locations where the firm might have sited its facility instead. Looking at contemporaneous attributes, race and income are both strongly correlated with plant location. However, at the time of siting, only income remains significant, perhaps because of the importance of local labor market conditions. Like labor costs, other variables associated with cost-minimization, including the labor skills, land costs, distance to rail, and agglomeration near other firms in the industry all are significant factors explaining firms' choices.

More recently, McCoy (2017) carries out a longitudinal analysis focused on the disparate siting of coal-fired power plants. The paper first shows evidence of current correlations between coal plant locations and racial and socioeconomic variables. Going back to examine these variables at the time of siting suggests that increasing environmental awareness led to siting of coal plants in communities of color.

4.2. Sorting

Charles Tiebout (1956) famously described a process whereby individuals "vote with their feet" for their preferred location. In his theory of residential sorting, desirable neighborhood amenities are priced into gross-of-tax home values. Individuals therefore must make trade-offs between consumption and a clean environment, as well as other local amenities like school quality, public safety, and so forth. How much a household is willing to pay for these amenities (or local public goods) depends on its preferences and income. Consequently, richer, higher-demand households will tend to sort together in high-amenity neighborhoods.

Tiebout sorting suggests an alternative explanation for disproportionate pollution exposures that characterize environmental injustice. Such exposures do not necessarily arise from disproportionate siting. Rather, siting could be neutral with respect to race and class, and disproportionate exposures still could arise ex post as a result of individuals' residential location decisions.

Banzhaf & Walsh (2008, 2013) provide a useful reformulation of the ideas in Tiebout's original work. Under the assumption that individuals' willingness to forego other consumption in exchange for an amenity is strictly increasing in income (i.e., the "single crossing" assumption), they demonstrate that communities will stratify according to income, with the poor sorting into more polluted neighborhoods. Furthermore, if income distributions are first order stochastically dominant across racial groups, such income sorting will induce correlation between pollution and race as well.

4.2.1. Environmental gentrification. The theory of Tiebout sorting has important implications for environmental justice (Been 1994; Been & Gupta 1997; Hamilton 1993, 1995; Banzhaf & McCormick 2012). It tends to push back the locus of injustice to the distribution of income and opportunity. It also links environmental exposure to housing costs. A polluted neighborhood might become cheaper, inducing income-constrained individuals to move in, a behavior often referred to in the literature as coming to the nuisance or minority move-in. The other side of the coin is that a neighborhood improvement can increase the demand for housing in an area, leading to move-in of richer households and an increase of housing prices; in other words, it can cause the neighborhood to gentrify.

Gentrification, or neighborhood change more generally, complicates our discussion of environmental improvements. It is typically a multidimensional process but has particular hallmarks (Banzhaf & McCormick 2012). These include rising property values and rental costs for a given level of housing services, increases in housing services through renovation and additions, increases in owner-occupied housing, and population turnover. The shifting local demographics also can induce a changing mix of retail and public goods and amenities. This process, often referred to as the Starbucks effect (O'Sullivan 2005), creates a new community aesthetic (e.g., new businesses, etc.), which can, in turn, induce further changes in socio-demographics and feedback effects on other endogenous amenities (e.g., crime rates).[5] These changes can also directly take place through political channels with voting on public goods like education spending.

Even more surprisingly, models of residential sorting in a context where individuals care about either the race or income of their neighbors have shown that segregation can actually increase in response to reduced income inequality (Sethi & Somanathan 2004) or reduced inequality in public good provision (Banzhaf & Walsh 2013). Implicitly, this increased segregation could potentially increase the share of the disadvantaged group experiencing pollution, even if pollution levels are decreasing in absolute terms.

Feedbacks of this sort often are described as general equilibrium effects. In the simplest terms, general equilibrium effects will directly impact the price of housing, which could lead to counterintuitive welfare effects of cleanup. In particular, people with weaker preferences for environmental quality (or who, alternatively, may have a higher marginal utility from income spent on necessities of life other than pollution avoidance) may choose to locate near pollution in order to get a cheaper house. Cleanup improves environmental quality, causing an increase in demand for that location by those who value a cleaner environment. Housing costs in the improved location will rise, and renters who are located there will no longer find it to be an inexpensive alternative. Instead, they may be forced to spend more on environmental quality that they do not value as much as they do other necessities. In terms of net welfare, they may even be made worse off by cleanup.

This discussion of general equilibrium effects highlights an important distinction between renters and owners; in particular, owners benefit from increased housing values accompanying an environmental improvement, while renters are harmed. Cleanup and reuse of locally undesirable land uses (LULUs) make neighborhoods more attractive, driving up local real estate prices. Whereas renters face higher prices, homeowners receive capital gains (but could also face higher property taxes). Illustrating this phenomenon, Sieg et al. (2004) take an equilibrium sorting model to housing and air quality data in southern California, finding in simulations that wealthier households move into initially low environmental quality areas following large air quality improvements and make poorer renters worse off.

Some have suggested that the phenomenon may be avoided, especially if environmental improvements are "just green enough" (Eckerd 2011, Curran & Hamilton 2012). But others have

[5]Take, for example, the broken windows effect (Wilson & Kelling 1982), a theory of norm-setting that states that preventing small crimes like vandalism can create a sense of order and lawfulness that, in turn, prevents more serious crimes. In the environmental justice context, the idea is that environmental improvements (e.g., redeveloping brownfields and making space more usable) will set off a series of feedback effects that reduce vandalism and small property crimes.

found evidence of environmental gentrification. O'Sullivan (2005) models these dynamics and discusses Portland, Oregon in the 1990s as a case study. Voorheis (2017) uses Internal Revenue Service (IRS) tax return data to track individual migration and pollution exposures over 2000 and 2014. He finds that air quality improvements have been large for those initially exposed to high levels of pollution; however, the largest improvements accrue to those who are higher income in the beginning of the sample, also suggestive of gentrification.

Grainger (2012) finds evidence of partial (but not complete) pass through of environmental improvements into rents. He finds that following air quality improvements induced by the Clean Air Act, owner-occupied housing increased in value, while rents increased but not as much, even conditioning on income of residents (see also Bento et al. 2015). Binner & Day (2018) estimate an equilibrium sorting model that incorporates the option to rent or own housing. They find large differences between the partial equilibrium welfare impacts of a local change in environmental quality and the general equilibrium ones, highlighting the scope for gentrification from environmental improvements that can subsequently trigger price changes and resorting. They also find evidence that welfare changes depend on tenure status: Homeowners benefit much more than renters in areas that experience increased housing demand. This has important consequences for environmental justice given racial disparities in wealth and rates of home ownership in the United States.

4.2.2. Longitudinal studies of sorting.

A number of studies have tested for either coming to the nuisance or environmental gentrification (or both), using longitudinal data. For the most part, these studies have tried to model dynamics by looking at changes in demographics following changes in environmental quality. They typically employ a regression of the following form:

$$\Delta\%R_j = \beta_0 + \beta_1 \Delta Q_j + Z_j'\beta_2 + u_j,$$

where $\Delta\%R_j$ is the change in the percentage of population of neighborhood j in racial group R; ΔQ_j is the change in environmental quality in neighborhood j or possibly lagged environmental quality; Z_j represents other neighborhood socio-demographics; and u_j captures unobservable (to the researcher) determinants of racial dynamics. The simple interpretation of this regression is that $\beta_1 > 0$ indicates fleeing the nuisance.

Studies that follow neighborhood dynamics after siting (or conversely, cleanup) include those by Been (1994), Oakes et al. (1996), Yandle & Burton (1996), Been & Gupta (1997), Lambert & Boerner (1997), Shaikh & Loomis (1999), Pastor et al. (2001), Baden & Coursey (2002), Morello-Frosch et al. (2002), Cameron & McConnaha (2006), Greenstone & Gallagher (2008), Banzhaf & Walsh (2008), Cameron et al. (2012), Gamper-Rabindran & Timmins (2013), Mohai & Saha (2015a,b), and Best & Rüttenauer (2017). Interestingly, Noonan et al. (2007) consider real estate and demographic effects jointly. Generally, evidence of sorting behavior has been mixed at best.

More recently, Banzhaf & Walsh (2013) and Depro et al. (2015) argue that finding evidence of residential sorting using the traditional empirical approach employed by these studies has proven difficult because individual sorting decisions are not identified by changes in aggregate neighborhood demographics. Banzhaf and Walsh point out that changes in demographics must be compared to changes at control sites, which themselves might be changing demographically in general equilibrium. Consequently, even when the correlation between race and pollution is generated solely by sorting on income (and, indirectly, by correlations between income and race), changes in pollution might not be correlated with changes in racial composition in the expected way. It depends on the relative demographic shares at the marginal portion of the income distribution in the treated areas relative to the controls. Moreover, as noted above, when households sort on endogenous demographics, cleanup can strengthen the correlation between race and pollution. These results are similar to the cautionary tale told by Kuminoff & Pope (2014) and Banzhaf (2018) about difference-and-differences relationships between housing prices and amenities.

Depro et al. (2015) underscore the fact that aggregate data do not track individual moves, and changes in pollution exposure depend on both the starting and ending pollution levels associated with a particular move. We typically do not have access to data on large numbers of individual moves and, using aggregate data, the regression of the sort described above is not capable of uniquely identifying individual preferences. Depro and colleagues instead show how this identification problem can be solved by applying additional structure to the model of the sorting decision. They implement such an approach using census data from Los Angeles County and corresponding pollution data from the National Air Toxics Assessment while controlling for pollution sources described in the TRI. Although the results of a traditional sorting model applied to these data suggest that it is whites who come to the nuisance while Hispanics flee it, the results of the structural model suggest that whites indeed have a stronger tendency than Hispanics to flee from cancer risk, meaning that the observed environmental justice correlation in Los Angeles could have a sorting, as opposed to strictly a siting, explanation. It is important to note, however, that this result does not imply that Hispanics do not care about pollution. Rather, it is likely a result of large discrepancies in income and the resulting differences in the marginal utility of income. In 1999, white per capita income in Los Angeles was $35,785, whereas Hispanic per capita income was only $11,100.

4.2.3. Discrimination in housing markets. The sorting literature has typically ignored housing market discrimination because it cannot be identified from traditional data sources. However, if discrimination is important, then we cannot expect all housing units to be freely chosen and, consequently, estimates of the values for different neighborhood attributes will be mismeasured. Essentially, the standard sorting models will omit shadow prices or misspecify the set of available substitutes. In the simplest terms, we may understate a minority group's willingness to pay for pollution reductions if those households live in a polluted neighborhood not by free choice but because of discrimination.

A robust literature has examined discrimination in the real estate industry, using matched-pair audit studies conducted by the US Department of Housing and Urban Development (HUD) in conjunction with university researchers and institutions. These papers focus on the likelihood that white and minority testers are recommended and then given the opportunity to inspect a property. Although not specifically focused on implications for exposure to environmental nuisances, these studies do quantify impacts on housing search. Christensen & Timmins (2018) summarize this literature and expand the analysis of HUD audit studies to include the impact of discrimination on the local public goods and amenities in the individual's housing choice set. Focusing on environmental disamenities, they find important implications for local air toxics and proximity to Superfund sites, especially for African Americans.

Inferring discrimination from equilibrium relationships, Cutler et al. (1999) find that in the early to middle part of the twentieth century, segregation was based on collective action taken by whites to exclude blacks, whereas in the later decades it was based on decentralized discrimination, in which whites paid more than minorities to live in white neighborhoods (white flight). Reexamining the early part of the twentieth century, Shertzer et al. (2016) find that, in the case of Chicago, early zoning laws appeared to steer high-density residential units and industrial activity toward minority areas. Cooper et al. (2016) document the long-run impacts of redlining on today's urban tree canopy.

4.3. Coasean Bargaining and Collective Action

Our first mechanism considered firm choices conditional on locational demographics; our second considered household locational choices conditional on environmental quality. Bringing the two together, the logic of Ronald Coase would posit that firms and households negotiate, directly or indirectly, for the environmental quality of an area, with firms having a willingness to pay for site polluting activity in a particular location and households having a willingness to accept (WTA) compensation for such activity.

The Coase theorem states that, if there are (*a*) no transaction costs, (*b*) no wealth effects on demand, and (*c*) well-defined property rights, then it does not matter who holds the property rights (e.g., to the use of air or water) because negotiation and market transactions will ensure the same allocation and use of property in a free market, which will prove to be the most efficient allocation as well (Coase 1960). Put simply, the right to the resource (to be kept clean or to be used for depositing wastes) will end up in the hands of the individuals who value it most through negotiation, and all parties will be appropriately compensated for any nuisance they bear as a result.

In a Coasean bargain, we assume that the WTA a unit of pollution reflects the local resident's marginal damages suffered from it. This is important, as polluters have an incentive to locate where damages (and, therefore, WTA of local residents) are low. Damages could be low either because there are few people located nearby (i.e., no one to suffer from the pollution) or because the WTA of local residents is low. The latter could result because low-income residents do not care about pollution or simply because they have a high marginal utility of income and are not willing to sacrifice consumption of other important goods in exchange for lower levels of pollution. In either case, Coasean bargaining theory would treat an allocation of pollution to poor neighborhoods as a result of low marginal damages as an efficient outcome. Jenkins et al. (2004) provide a direct analysis of Coasean bargains, examining the host fees paid by privately owned solid waste landfills in 1996. They find evidence that citizen participation is an important determinant of fees.

There are, however, other factors that might reduce WTA that would not reflect actual damages. Moving beyond his famous theorem, Coase argued that transactions costs of various kinds would affect the final allocation of resources. For example, if a disadvantaged group is unable to fully and effectively express its disutility from pollution exposure, it may come to the bargaining table with a WTA that is too low. This may happen, for example, if the community lacks the impetus for collective action (e.g., if most residents are renters, they may not feel invested in the community and be willing to incur costs to organize in support of something that has many public good attributes), as discussed by Hamilton (1995). Considering polluting facilities with and without planned expansions, Hamilton finds that those with planned expansions had, on average, a higher percentage of nonwhite population, lower household median incomes, lower population density, a higher percentage of families below the poverty line, and lower voter turnout. In addition, information or language may create barriers—if residents are ill informed about the dangers they face, for example, about the environmental and property laws, or about the right way to find legal expertise and negotiation, the reservation prices they express may not reflect their true preferences. The polluter's payoff will be higher in this situation, giving the polluter an incentive to seek out these sorts of communities. As Coase emphasizes, these outcomes are still efficient, given the high—and very real—costs that households face when bargaining. However, this statement is to merely push back the locus of injustice to the distribution of access to power. It also provides a perspective on the work of the environmental justice movement in facilitating such transactions (Banzhaf et al. 2018a).

There is real-world evidence that the ability to organize affects siting decisions. In particular, the California Integrated Waste Management Board commissioned a now infamous report by Cerrell Associates in 1984 (Powell 1984) to study the political barriers to siting 29 waste-to-energy plants. That report concluded that "the most formidable obstacle to waste-to-energy facilities is public opposition" (Powell 1984, p. 2). It went on to say that

> [a] great deal of time, resources, and planning could be saved and political problems avoided, if people who are resentful…could be identified before selecting a site. If this information was available, facilities could be placed in an area…where people do not find them so offensive. (Powell 1984, p. 11)

A similar outcome would arise in a situation where those bargaining on behalf of victims are not actually those bearing the costs of the pollution. This story could arise from geography, if the seat of power lies far from the site where the pollution impact is felt; see, for example, the case of Kettleman City, California, described in Cole & Foster (2001). In this case, a region's toxic waste is disposed of in one particular neighborhood, but the tax revenues and employment engendered by the waste firm's operations accrue to individuals outside that area. A situation like this might also arise if a disadvantaged community is poorly represented by the local government. This could be the result of outright discrimination (i.e., where elected officials downweight the votes of certain groups), or some other aspect of local government structure. In general, when property rights are not well defined, rent seeking and other political economy pressures can steer outcomes in inefficient and inequitable ways, influencing regulators as well as legislators.

4.4. Government (In)Action and Regulatory Stringency

Regulators must choose how to allocate the policy tools at their disposal, prioritizing regulation and remediation across various sites in the face of resource and time constraints. Decisions are based on technical factors (e.g., size of operating facility, hazardousness of processed materials, potential risks to surrounding neighborhood, complexity of pollutant mix, interplay with urban environment), polluter factors (e.g., seriousness of offense, polluter's ability to pay, polluter's violation history, polluter's negotiation/bargaining power), and the preferences of interest groups that may capture the regulatory process. This raises the possibility that the application of pollution regulation could be a source of inequitable exposure to environmental nuisances. Noonan (2008) and Sigman & Stafford (2011) review the literature on the determinants of regulatory activity at and cleanup of contaminated sites and the methods used to measure the influence of community characteristics. Shimshack (2014) similarly reviews institutions responsible for environmental enforcement and empirical evidence on regulator behavior and its deterrent effect. Results in this literature, particularly with respect to racial disparities, are mixed.

Lavelle & Coyle (1992) examined a large number of US environmental lawsuits and concluded that polluters in areas with larger minority populations faced lower penalties than their predominantly white counterparts. Ringquist (1998) and Atlas (2001), however, do not find evidence of this pattern. Greife et al. (2017) study the relationship between community demographics and monetary penalties leveled against corporations for violations of federal environmental law and find no relationship with local community demographics.

Research has gone on to study the application of regulation and other pollution policies, with a particular focus on whether this is done equitably and whether inequities in application could be responsible for environmental injustice. For example, Jenkins & Maguire (2012) study the application of hazardous and solid waste taxes, testing whether racial makeup affects tax rates. Controlling for multiple factors (e.g., the size of the external costs associated with the waste, state revenue requirements, interjurisdictional competition with other states, interplay between state and local government), they find that race does not appear to have an independent effect.

A number of studies have examined the role of community characteristics in affecting environmental enforcement and pollution abatement activity by plants. Becker (2003) examines air pollution abatement activity and finds that it increases with per capita income, homeownership, Democratic voters, and whether a plant is located within a metropolitan area, but it decreases with the presence of manufacturing employees. Gray & Shadbegian (2004) and Shadbegian & Gray (2012) study the determinants of penalties and the frequency of inspections by state regulators in the United States. Controlling for factors that affect the marginal costs of enforcement, they find that the potential for collective action is an important determinant of regulatory stringency, but that pollution levels are actually lower in minority areas, while the correlation with income is mixed. Konisky (2009) similarly measures the effect of community characteristics on enforcement related to the Clean Air Act, Clean Water Act, and RCRA. He finds strong evidence that enforcement is lower in poor counties but little evidence of inequities by race. Focusing on the Clean Water Act and using areal apportionment methods to define local population characteristics, Konisky & Schario (2010) find modest evidence that race affects inspections and punitive actions in response to complaints. Using data on RCRA inspections, Spina (2015) finds evidence of disparities based on race, age, and social disorganization. Konisky & Reenock (2013) show that these sorts of biases can be mitigated by political mobilization or decentralized enforcement authority within the relevant agency.

Studies have also looked at remediation activity. Hird (1993) shows that the likely beneficiaries of the Superfund program activities are those living in counties characterized by higher wealth and education, but that potential hazard levels drive the pace of cleanup. Sigman (2001) finds little evidence that Superfund sites are prioritized by the EPA according to their harms but that priorities are set by the interests of local communities and, in particular, liable parties. Viscusi & Hamilton (1999) focus on the choice of post-cleanup standards in remediation and whether risk perceptions and political factors divert regulators from choosing the social welfare–maximizing values of cancer risk target (after remediation) and cost per cancer case averted. The authors find (perhaps surprisingly) that higher minority percentages lead to stricter risk targets. The same is also true (less surprisingly) of greater potential for collective action.

A number of case studies, though anecdotal, paint a detailed picture of ways in which regulation may fail disadvantaged groups—often by improperly reflecting their preferences in siting decisions, or by failing to enforce rules about emissions post-siting. Take, for example, the siting and construction of the North River Wastewater Treatment Plant in predominantly African American West Harlem in the late 1970s (Sze 2006). Other useful case studies include the siting and construction of the Genesee Incinerator and Power Station in Flint, Michigan in 1991; Chemical Waste Management's proposed toxic waste incinerator in Kettleman City, California in 1988; Chester Residents Concerned for Quality Living's (CRCQL) campaign against a medical waste incinerator in Chester, Pennsylvania in 1993; and the landfill in Warren County, North Carolina, which sparked the environmental justice movement.

4.5. Intergenerational Effects of Pollution

Exposure to environmental nuisances can have deleterious long-term impacts on human capital and earning potential. This provides a mechanism through which pollution exposure extends poverty (and subsequent pollution exposure) to the next generation, an avenue for a different type of feedback effect than those previously described. In economics, assessments of these effects have focused on overcoming the hurdle of empirically distinguishing the effect of the neighborhood per se from that of selection, i.e., the effect of other aspects of the lives of the types of people who live in the neighborhood.

Typically, researchers have assessed these impacts in two steps. First, do environmental nuisances affect birth outcomes? And, second, do birth outcomes impact later-life outcomes? A large literature finds evidence that nuisances from various environmental media, including air, water, and land, negatively affect birth outcomes, such as birth weight, gestation length, congenital abnormalities, and infant mortality (see Šrám et al. 2005 for a review). Subsequently, several papers demonstrate that neonatal health can impact later socioeconomic status, supporting the so-called fetal origins hypothesis (Almond & Currie 2011, Almond et al. 2017). This includes adult health (e.g., diabetes), education, labor force outcomes, and adult poverty (Black et al. 2007, Oreopoulos et al. 2008, Barreca 2010, Almond et al. 2012, Figlio et al. 2014, Currie et al. 2014). For example, Black et al. (2007) find that weight differences at birth impact IQ, adult height, earnings, and educational attainment.

Additionally, research has more directly connected pollution exposure in utero and in early childhood to later-life outcomes. Currie (2011) demonstrates that exposure to pollution while in utero is lower for more educated mothers but higher for minority mothers and that the resulting differences in exposures to toxic releases can explain differences in low birth weight. Voorheis (2017) uses a unique combination of data linking responses to the American Community Survey to Social Security Administration data and the universe of IRS 1040 tax returns to measure the effect of pollution exposure at birth on college attendance. He translates the effect of an additional unit of particulate matter on subsequent annual wages as an adult and also finds impacts of particulate matter exposure at birth on incarceration rates and high school non-completion, particularly in disadvantaged communities. Persico et al. (2016) use population-level data on those born in Florida between 1994 and 2002 to examine the impacts of prenatal exposure to nearby Superfund sites. Children conceived before cleanup are found to exhibit significantly worse performance in several schooling outcomes and are more likely to be diagnosed with a cognitive disability.

A key feature of many of these studies is to deal with the selection problem by measuring the outcome of interest (e.g., birth weight or earnings) in response to some change in the environment (or, in the second case, neonatal health), while ensuring that those that do not experience the change (the control group) represent a valid counterfactual. For example, Black et al. (2007) estimate the short- and long-run impacts of birth weight differences by exploiting weight differences between twins. Persico et al. (2016) establish causality by using family fixed effects and considering siblings where at least one sibling was conceived before or during site cleanup while the other was conceived after the completion of cleanup. In avoiding comparisons of infants born to different mothers, these studies are better able to limit the impact from other unobserved differences across mothers (e.g., income, education, mobility) that are correlated with birth weight or pollution exposure that can also affect the outcome of interest.

In this vein, other studies have directly explored the intergenerational connection. For example, Currie & Moretti (2007) show that if a mother was low birth weight, her child is significantly more likely to be low birth weight as well, and that this effect is stronger for mothers from high-poverty zip codes. Moreover, the authors show that this effect holds even when they compare sister pairs. Currie (2009) finds strong links between the socioeconomic status of parents and the health of their children, and between child health and human capital and labor market returns later in life.

The point is that inequitable exposures today may be compounded through these intergenerational feedback effects. Intergenerational transmission may render policies unsuccessful at correcting disproportionate exposure, given a battery of other disadvantages that are mixed in with being born into polluted areas. Moreover, it suggests that what may be optimal for individuals today may not be optimal overall once dynamic costs are taken into consideration.

5. POLICY INCIDENCE

As pollution is unevenly distributed with respect to race and income, one might infer that any improvement in environmental quality should disproportionately benefit the disadvantaged. However, Banzhaf (2011) highlights the importance of considering the costs as well, especially given the evidence that these costs may be regressive. In addition to the gentrification effects discussed earlier, environmental regulation is potentially regressive because a larger share of a low-income household's budget is allocated toward pollution-intensive goods (Robinson 1985), like fuel and electricity (Hassett et al. 2009, Grainger & Kolstad 2010). On net, it is unclear whether policies with the intention of improving distributive outcomes leave the disadvantaged better or worse off. If regulations, on net, leave individuals relatively poorer, then, combined with the various channels through which poverty can constrain household decisions, regulatory efforts to curb pollution, such as a tax or a cap-and-trade scheme, can actually reinforce its inequitable distribution.

While this is the case, researchers have noted that the extent of a policy's regressivity varies greatly and in some cases can even be progressive. The direction depends on several factors. First, the measurement of current as opposed to lifetime income matters, because people who seem poor at a particular point in time may not be if they are able to draw from savings or other forms of wealth (Hassett et al. 2009). Distribution also depends on how policies affect the returns to production inputs and factor prices (Fullerton & Heutel 2007, 2010; Rausch et al. 2010) or, generally, aspects that prevent complete pass-through of higher prices to consumers (Borenstein et al. 2002, Parry 2004, Burtraw et al. 2009, Grainger 2012). Less pass-through tends to hurt firms or the owners of capital, who are more likely to have higher incomes.

Levinson (2019) explores the relative incidence of the carbon tax versus fuel efficiency standards. Beginning with the well-established idea that energy taxes are regressive, he notes that energy is a normal good, and richer households will therefore have an incentive to invest more heavily in energy-efficient appliances. Policies that tax energy-inefficient appliances (or subsidize the efficient ones) will therefore be even more regressive than a simple Pigouvian carbon tax.

Several studies have evaluated the distributional effects of large-scale markets like cap-and-trade. Unless firms with higher abatement costs systematically lie upwind of environmental justice communities, there is no a priori reason why we would expect pollution trading to worsen such correlations. Perhaps for this reason, the empirical literature has not found any clear consensus about how permit trading affects the distribution of pollution (Shadbegian et al. 2007, Fowlie et al. 2012, Bento et al. 2015, Grainger & Ruangmas 2018, Meng 2018). Bento et al. argue that the gross benefits of pollution reductions, as measured by capitalized housing prices, are progressive.

The way in which revenues from policies are recycled (e.g., replacing regressive taxes) can render the distribution of costs more or less progressive (Metcalf 1999, Burtraw et al. 2009, Araar et al. 2011). Relatedly, if the government does not raise any revenues in an emissions trading setting because permits are freely allocated to firms, then it would pose a disproportionate burden on the poor since permit rents go to shareholders, who again are likely to have higher income (Parry 2004). Other aspects of policies can have effects as well, including indirect price impacts on other products that use energy (Hassett et al. 2009, Shammin & Bullard 2009), liquidity constraints that limit the usefulness of lump-sum rebates for the poor (Galle & Utset 2010), and indexing of government transfers, which are also used mostly by the poor (Fullerton et al. 2011). See Parry et al. (2006) and Fullerton (2011) for an overview of these issues.

Holland et al. (2019) explore the incidence of policies to promote the adoption of electric vehicles, finding that these policies have large benefits to urban residents who are densely settled in areas with heavy traffic congestion, while the policies have costs for those living downwind of the power plants tasked with making the energy to recharge those vehicles; these costs are particularly high in parts of the country that rely heavily on coal for power production.

Employment is another area of environmental justice concern if the poor and nonwhite tend to hold jobs in polluting industries. This not only affects the distribution of environmental impacts depending on the industries that are most heavily affected (Holmberg 2017) but also impacts the costs of environmental policy given the potential trade-off between environmental protection and job opportunities (Beasley 1990). Ash & Boyce (2016) test this using TRI facility-level data that are matched to US Equal Employment Opportunity data. They do not find a significant relationship between employment and pollution risk but find that the share of pollution borne by blacks and Hispanics is 1.5 times higher than each of the group's employment shares at TRI facilities. This suggests that the negative employment effects from environmental improvements are likely to be low.

6. CONCLUSIONS

A large literature has developed over the last 30 years that documents the disproportionate exposures to pollution borne by the poor and people of color. Over time, the literature has paid more attention to exactly what it means to be exposed to pollution, the distinction between race and class, and tackling difficult statistical problems associated with the definition of spatial units (i.e., the ecological fallacy).

However, simply identifying whether an environmental inequity exists is not sufficient. In order to devise policies to redress these injustices, we need to know their origins. We have posited three primary explanations for environmental injustice that have roots in economic theory: siting, sorting, and Coasean bargaining. In a textbook case, the Coase theorem provides a mechanism by which we would expect private negotiations over pollution to yield socially optimal outcomes and make both parties—the polluter and the victim—better off. Why then, is the environmental justice literature filled with case studies where this does not appear to be the case? There are many reasons tied to race, class, and other sources of disadvantage (e.g., language) that lead us to suspect that Coasean bargaining will not always follow the textbook model. In particular, groups disadvantaged because of race or poverty may not always be able to express their true value for a cleaner environment in a Coasean bargain. When property rights are unclear, parties may try to claim them through political action. In a representative government, a community's preferences may not be accurately reflected by their elected officials. In either case, negotiations would lead to an inefficient outcome. Moreover, polluters would have an incentive to seek out such disadvantaged groups in their siting decisions, simply out of cost-minimizing incentives.

If inequitable siting were the sole cause of environmental injustice, the solution would simply be to redesign permitting and zoning rules. Disproportionate exposure, however, may result from the residential location decisions of individuals making income-constrained decisions in housing markets following the siting of an environmental nuisance. We introduced this idea in the context of Tiebout sorting—the idea that individuals express preferences for neighborhood attributes (including environmental quality) relative to other goods and services by their willingness to pay more for housing services in a less polluted area. Housing markets will capitalize neighborhood amenities into housing prices, making houses in more polluted neighborhoods, ceteris paribus, less expensive. Under diminishing marginal utility of income, poor individuals will be less willing to forgo other necessities in exchange for living in a less polluted neighborhood; we may therefore see them coming to the nuisance. Simply changing zoning rules may therefore reduce inequitable exposure to pollution in the short run, but this could be undone in the long run by resorting behavior.

Both the siting and sorting explanations for environmental injustice depend, at their core, on income disparities. Dealing with disproportionate exposure to pollution and environmental injustice may, therefore, require first addressing a much harder problem—income inequality.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

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Annual Review of
Resource Economics

Volume 11, 2019

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