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Environmental Justice: The Economics of Race, Place, and Pollution

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In 1978, 31,000 gallons of polychlorinated biphenyl (PCB)—a highly dangerous chemical—were illegally dumped on behalf of the Ward Transformer Company across 14 counties in North Carolina. The state collected the contaminated soil and identified two landfill sites for the waste: a publicly owned landfill in Chatham County, and a recently foreclosed property in Warren County. The Warren County site had a shallow water table, making it unsuitable for a landfill. However, the site was privately owned and near a town with no mayor or city council. In contrast, the Chatham County site was publicly owned, giving local residents an opportunity to participate in the siting decision. Additionally, in 1980, Warren County was 60 percent black and 25 percent of its families were below the poverty line (and the area immediately near the site had even higher proportions of people of color), whereas the corresponding figures for Chatham County were only 27 percent and 6 percent. Ultimately, the state placed the landfill in Warren County. Protests over this decision drew widespread support from civil rights groups and gained national media attention. The environmental justice movement was born (for a detailed description of this episode, see Hampson 2010).

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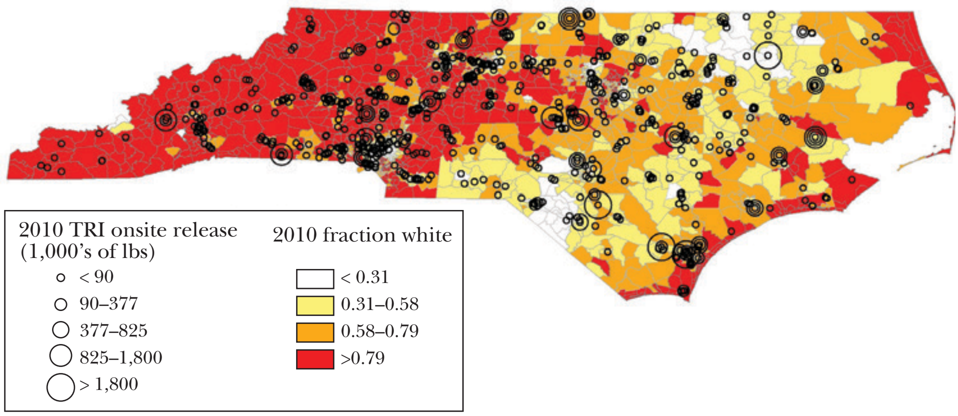
The grassroots movement that placed environmental justice issues on the national stage was soon followed up by research documenting the correlation between pollution and race and poverty (Bullard 1983; US GAO 1983; Commission for Racial Justice, United Church of Christ 1987). Since then, a growing body of academic work in law, sociology, public policy, geosciences, and economics has further investigated such correlations under a variety of measures of exposure, spatial scales, and statistical controls. This work has established inequitable exposure to nuisances as a stylized fact of social science. Useful overviews of this literature include Bullard (1994), Cole and Foster (2001), Bowen (2002), Ringquist (2003, 2005), Noonan (2008), Mohai, Pellow, and Roberts (2009), and Banzhaf (2012).

Figures 1–3 offer an example of the evidence behind such correlations, in this case the correlation between demographics and the location of large polluters identified in the Toxic Release Inventory (TRI), a national database established by law which requires private and government facilities to report annually how much of certain chemicals they emit into air or water or send to landfills. Figure 1 plots emissions from these polluters in North Carolina in the year 2010 with circles, against a heat map of the percentage of the population that is white at the census tract level. The correlation between the population density of people of color and emissions intensities at these facilities is striking. A simple calculation finds that the share of 2010 sites operating in tracts that are more than 80 percent non-Hispanic white is about double the share in tracts that are more than 80 percent non-white (22 versus 10 percent). Yet, there are almost five times as many mostly white tracts as there are tracts predominantly of people of color (788 versus 166). Figure 2 next maps emissions against income at the county level. Zooming in on a particular area of Figure 2, Figure 3 shows that facilities are disproportionately located in the lower-income tracts within the county. In this case, the share of TRI facilities operating in tracts with per capita income below $21,000 is 63 percent.

Such correlations indicate, but do not fully encapsulate, the concerns of the environmental justice movement. These concerns pertain both to distributive justice (relating to the distribution of environmental burdens) and to procedural justice (relating to the decision-making processes that lead to those distributions). For example, the US Environmental Protection Agency defines "environmental justice" as requiring that "no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies" and calls for "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."[1] More generally, environmental justice dovetails with the growing concern about income inequality (for example, Chetty, Hendren, Kline, Saez, and Turner 2014; Piketty 2014). Because public goods are part of

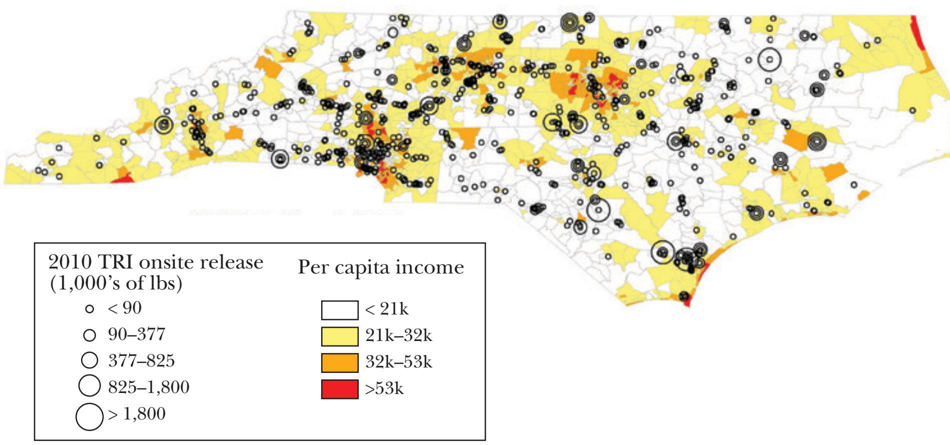
[1] See the EPA webpage "Learning about Environmental Justice" at https://www.epa.gov/environmentaljustice/learn-about-environmental-justice.

Figure 1
Emissions from Large Polluters and Fraction Non-Hispanic White for North Carolina, 2010



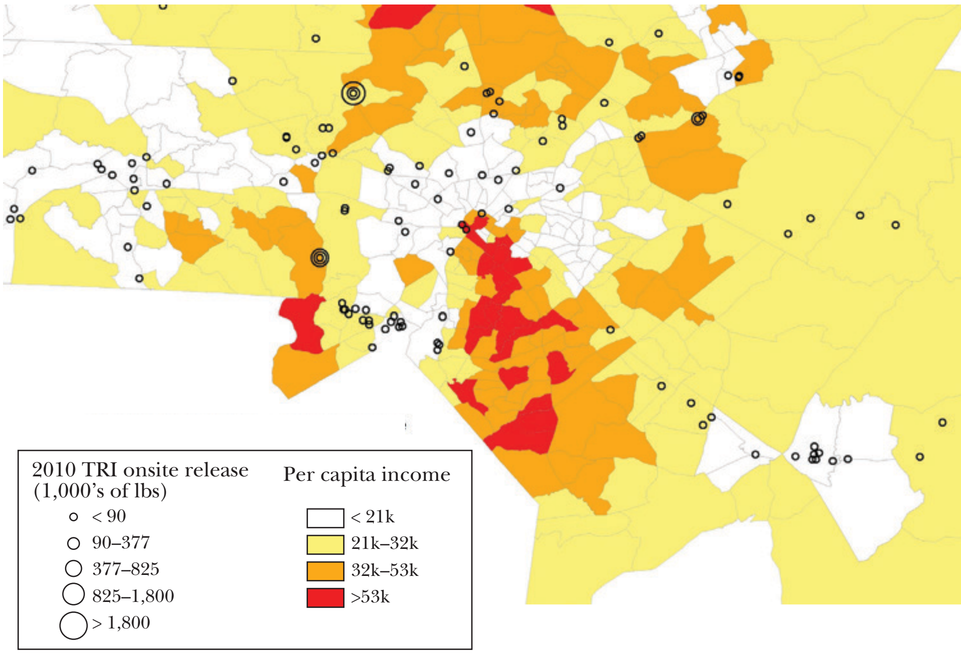
Source: Authors using data from the Toxic Release Inventory and US Census.
Note: Using data from the Toxic Release Inventory (TRI), Figure 1 plots emissions from large polluters in North Carolina in the year 2010 with circles, against a heat map of the percentage of the population that is non-Hispanic white at the census tract level.

Figure 2
Emissions from Large Polluters and Per Capita Income for North Carolina, 2010



Source: Authors using data from the Toxic Release Inventory and US Census.
Note: Using data from the Toxic Release Inventory (TRI), Figure 2 plots emissions from large polluters in North Carolina in the year 2010 with circles, against a heat map of income at the census tract level.

Figure 3
Emissions from Large Polluters and Per Capita Income, Part of North Carolina, 2010



Source: Authors using data from the Toxic Release Inventory and US Census.
Note: Using data from the Toxic Release Inventory (TRI), Figure 3 plots emissions from large polluters in a part of North Carolina in the year 2010 with circles, against a heat map of income at the census tract level.

households' real income, the distribution of environmental amenities is part of the overall landscape of inequality.

In this paper, we review the environmental justice literature, especially where it intersects with work by economists. Although environmental justice is an interdisciplinary field, economists' focus on causal relationships, and on linking empirical models to theoretical ones, gives them a comparative advantage in untangling the web of socioeconomic relationships involved. In the next section, we first consider in more depth the literature documenting evidence of disproportionate exposure, such as that offered by Figures 1–3. We particularly consider the implications of modeling choices about spatial relationships between polluters and residents, and about conditioning variables. Next, we evaluate the theory and evidence for four possible mechanisms that may lie behind these patterns: disproportionate siting on the firm side, "coming to the nuisance" on the household side, market-like coordination of the two, and discriminatory politics and/or enforcement. We argue that it is unclear how much weight each of these mechanisms carry in giving rise to the observed distribution, and that much previous research uses methodologies that are inherently indecisive. Further research is needed, as we cannot hope to address injustices if we do not understand their origins. Finally, we offer an overview of some policy options before concluding.

Our discussion is focused almost exclusively on US topics, although similar questions have arisen in many parts of the world, including questions about land use, forest preservation, international disposal and management of toxic (including electronic) waste, and the disproportionate impacts of climate change. While there may be additional considerations with respect to the global or international nature of these cases, much of our discussion in the US context applies.

Modeling Exposure to Environmental Hazards

Early empirical work in environmental justice focused primarily on the demographics of people living near undesirable land uses such as hazardous waste sites and landfills.[2] Other papers have considered large air polluters, such as those listed in the US Toxic Release Inventory.[3] However, proximity to nuisances may not capture actual risk exposure. Not every hazardous waste site handles an equal amount of waste, nor does every TRI site emit an equal amount of pollution. Moreover, pollutants vary in their toxicity. For example, beryllium (released from the burning of coal) is over three million times more hazardous as an air toxic than the same amount of dichlorotetrafluoroethane (often used as a refrigerant). Accordingly, some researchers have considered emission levels (for example, the weight of releases) and chemical toxicity rather than simply proximity to a site when defining exposure.[4] Others have gone further by incorporating air quality models that characterize air pollutant dispersion across space, the better to capture the actual health hazards that populations face.[5]

Overall, while recent work has developed more nuanced and defensible measures of exposure, the overall finding that low-income households and people of color have greater exposure to environmental hazards is broadly supported by the application of these alternative measures. Moreover, the patterns seem persistent: following up on its seminal report of 1987 documenting environmental justice correlations, the United Church of Christ (Bullard, Mohai, Saha, and Wright

[2] Work along these lines includes Anderton, Anderson, Oakes, and Fraser (1994), Baden and Coursey (2002), Been (1997), Boer, Pastor, Sadd, and Snyder (1997), Cameron, Crawford, and McConnaha (2012), Currie (2011), Depro, Timmins, and O'Neil (2015), Gamper-Rabindran and Timmins (2011), Goldman and Fitton (1994), Persico, Figlio, and Roth (2016), Commission for Racial Justice, UCC (1987), and Bullard, Mohai, Saha, and Wright (2007).
[3] Examples include Ringquist (1997), Sadd, Pastor, Boer, and Snyder (1999), and Wolverton (2009).
[4] Examples include Arora and Cason (1999), Banzhaf and Walsh (2008, 2013), Bowen, Salling, Haynes, and Cyran (1995), Brooks and Sethi (1997), Kriesel, Centner, and Keeler (1996), and Ringquist (1997).
[5] Examples include Ash and Fetter (2004); Depro and Timmins (2012); Depro, Timmins, and O'Neil (2015); Morello-Frosch and Jesdale (2006); and Morello-Frosch, Pastor, and Sadd (2001).

2007) found that disparities in race with respect to the location of hazardous waste remained largely unchanged 20 years later.

Statistical Controls: The Locus of Injustice

The most basic—and most robust—environmental justice pattern in the data is the simple correlation between pollution and poverty and/or people of color. But, in the context of linear regression, questions arise as to the importance of additional statistical controls. In an influential study that first questioned the robustness of some environmental justice research, Anderton, Anderson, Oakes, and Fraser (1994) found no evidence that race is significantly correlated with the location of waste facilities after including socioeconomic controls. Instead, they found that the most salient feature was the intensity of manufacturing employment, suggesting that the observed correlations may arise through local matching in the labor market, rather than matching pollution per se to residents. Similarly, a number of subsequent studies have questioned whether race is still significant after conditioning on income and proxies for wealth, or other characteristics of land and neighborhoods that might drive firms' production decisions. Others have criticized the methods used by Anderton et al. with respect to spatial relationships (Mohai and Saha 2006; Mohai, Pellow, and Roberts 2009), a point to which we return below.

Faced with these questions of robustness of the results, our view is that the literature has tended to dive too quickly into technical discussions of data aggregation and estimation, without pausing to consider the *question* being asked. If the question is about determining the social *causes* of environmental justice correlations, it may well make sense to include statistical controls. For example, Mohai and Bryant (1992) and Hamilton (1995) posit a number of reasons why racial groups may be directly correlated with exposure even after controlling for income and wealth, including taste-based discrimination by firms, racial discrimination in the housing market, and differential political clout and access to legal resources. A finding that race is not correlated with pollution after controlling for socioeconomic status might lead one to reject some of these hypotheses. Similarly, a study of firms' siting decisions (like Wolverton 2009) might want to control for the costs of land, labor, and transport, which are likely to affect a firm's profits.

On the other hand, it is not clear that it is important to distinguish race from class when establishing the *existence* of an environmental inequity. One could still argue that there is an injustice—even an injustice at the level of racial groups—when there are inequities in the simple correlations, even if these correlations are the result of socioeconomic processes. Simply because the inequity is mediated through some mechanism does not mean it isn't there.

Spatial Relationships

Until recently, environmental justice studies typically assumed that the population "exposed" to a nuisance coincides with those people living in the same geographic unit as the nuisance, such as a census tract or zip code—an approach known as "unit-hazard coincidence" (McMaster, Leitner, and Sheppard 1997; Mohai and Saha 2006). The unit-hazard coincidence approach is straightforward, but is problematic for at least three reasons. First, it implicitly assumes that exposure to hazards is distributed equally within the geographic unit. However, geographic units like counties and census tracts vary greatly in size. For example, census tracts are drawn to have similar numbers of people, which means they are smaller in more densely populated urban areas. Unit-hazard coincidence thus assigns a smaller exposure area around facilities in more urban areas. Second, when nuisances are located near geographical boundaries, unit-hazard coincidence ignores exposures in adjacent areas that may be quite close by, while assigning exposure to parts of the coincident geographic unit that may be far from the nuisance. This introduces measurement error, which is likely to attenuate estimates of environmental justice correlations. Third, when geographic units like tracts are created to be fairly homogenous, the unit-hazard approach will mechanically extend local correlations to wider areas. For example, perhaps only a very local area near a nuisance is made up of one demographic group, but through the creation of homogeneous geographic units, that local area will be systematically combined with similar areas even if they are randomly distributed. This would tend to exaggerate any environmental justice correlations.

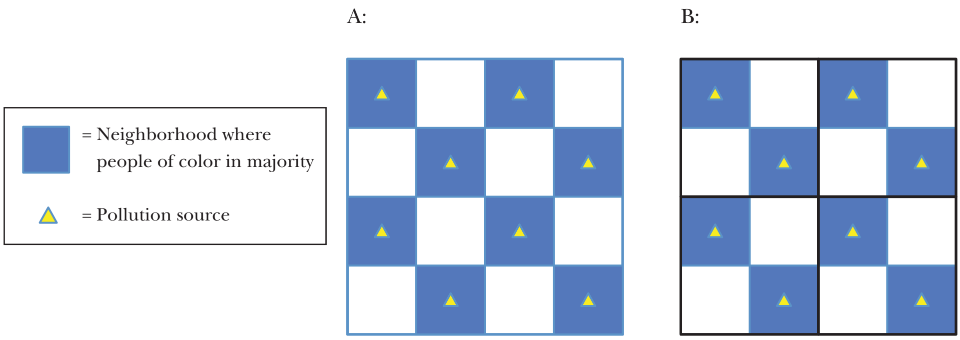
An alternative approach to measuring pollution exposure looks at the population within some distance of a site (or, alternatively, the nuisances or emissions near an arbitrarily drawn geographic unit). In the context of multiple regression and the question of sensitivity to included regressors discussed above, Mohai and Saha (2006) and Ringquist (2005) find that race is more likely to remain correlated with pollution when using distance-based measures rather than unit-hazard coincidence. Additionally, Mohai and Saha show that employing the unit-coincidence definition results in both larger tracts in the treatment group as well as tracts whose centroids are farther from facilities, compared to a distance-based measure. These patterns increase the likelihood of misclassifying exposure. This, along with the growing availability of new spatially resolute geocoded microdata and GIS technologies to analyze them, leads us to conclude that distance-based measures are superior to unit-coincidence.

Spatial Scale: The Ecological Fallacy

When measuring the correlation between pollution and demographics, the "ecological fallacy" can arise when inferring relationships between individual units (like households) from larger, more aggregated units (like counties) that contain those units. Some authors have raised concerns that the observed correlations between race and pollution found at the larger community level may potentially be subject to the ecological fallacy (for example, Anderton et al. 1994).

Figure 4 illustrates this concept. In Figure 4A, pollution sources (denoted by small triangles) are perfectly correlated with neighborhoods in which people of color are a majority (represented by larger, shaded squares), leading one to conclude that pollution is perfectly correlated with race. Suppose, however, that this relationship is estimated based on larger units of geography that aggregate neighborhoods according to the bold, dark lines in Figure 4B. Instead of 16 neighborhoods, the

Figure 4
The Ecological Fallacy



Note: Figure 4 illustrates the ecological fallacy. In panel A, pollution sources (denoted by small triangles) are perfectly correlated with neighborhoods in which people of color are a majority (represented by larger, shaded squares), leading one to conclude that pollution is perfectly correlated with race. Suppose, however, that this relationship is estimated based on larger units of geography that aggregate neighborhoods according to the bold, dark lines in panel B. Viewed at this more aggregated level, white neighborhoods and neighborhoods with people of color are now equally exposed to pollution sources, so one would conclude that there is no correlation between race and pollution.

data now is viewed as containing only four neighborhoods. Viewed at this more aggregated level, white neighborhoods and neighborhoods with people of color are now equally exposed to pollution sources, so one would conclude that there is no correlation between race and pollution.

The ecological fallacy teaches that the relationship estimated from aggregated data is only equal to the relationship at the micro level if there are no group-level effects correlated with pollution. This extreme assumption is not likely to hold. For example, if individuals have any peer preferences creating segregation between larger geographic units, or if the boundaries of geographic units are systematically gerrymandered in some way, we might expect exaggerated findings of correlations between pollution and demographics at a higher geographic level. If, on the other hand, communities follow a chessboard-like configuration due to clustering (as illustrated), then aggregation can mask inequitable exposure.

Baden, Noonan, and Turaga (2007) surveyed 110 environmental justice studies to assess the impact of the unit of analysis on their findings. They also conducted their own analysis to examine exposure to hazardous waste sites. Overall, they find that evidence of racial, ethnic, and income inequities becomes stronger when using smaller units of analysis (like tract and block group). Our earlier example contrasting Figures 2 and 3 illustrates these differences as well.

More recently, with increased data availability and advancements in computing, studies have employed individual-level data. In work that uses around 11 million births across five states between 1989 and 2003, Currie, Greenstone, and Moretti (2011) compare the characteristics of mothers in areas within two kilometers of

Superfund and TRI sites to those living farther. They find that black mothers are respectively 0.7 and 5.3 percentage points more likely to live near Superfund and Toxic Release Inventory sites; for Hispanics the respective values are 0 and 4.0. The results of many similiar studies in recent years likewise echo the persistence of these environmental inequities (for example, Currie and Neidell 2005; Currie, Graff-Zivin, Meckel, Neidell, and Schlenker 2013; Persico, Figlio, and Roth 2016). It thus seems that the ecological fallacy tends to mask environmental injustices in more aggregate data, rather than the reverse.

Harms of Disparate Environmental Exposure

Ultimately, concerns about environmental justice come down to inequities in health outcomes. But does inequitable pollution exposure actually translate into inequitable outcomes? Plenty of indirect evidence suggests that it does. A large epidemiological literature has established a correlation between air pollution and human health, even conditioning on demographics like race and income (for a review, see Hoek et al. 2013). More recently, a wave of "quasi-experimental" studies has corroborated this finding and given it a stronger causal interpretation, especially for outcomes in young children, but also adults (Chay and Greenstone 2003; Currie and Neidell 2007; Currie and Walker 2011; Currie, Davis, Greenstone, and Walker 2015; Schlenker and Walker 2016). The results seem to hold for proximity to Superfund sites as well (Currie, Greenstone, and Moretti 2011; Persico, Figlio, and Roth 2016).

Given that the poor and minorities live closer to Superfund sites and to large air polluters, it stands to reason that they suffer more from the adverse consequences of such proximity. Consistent with this interpretation, Chay and Greenstone (2003) find that the county-level impact of large changes in Total Suspended Particulates on infant mortality for blacks is 1.6 times that for whites. If there are no racial differences in the biological responses to pollution, then these disparate health affects must come either from differences in other socioeconomic factors (like interactions with other burdens from poverty) or from uneven exposure to pollution within a county.

The effects on educational attainment and health of young children raise additional considerations about intergenerational equity. The "fetal origins" hypothesis (discussed in this journal by Almond and Currie 2011) posits a biological mechanism through which *in utero* health can persist through adulthood and affect long-term health, human capital accumulation, labor market outcomes, family structure, and welfare dependency (on this topic, see also Black, Devereux, and Salvanes 2007; Currie and Moretti 2007; Oreopoulos, Stabile, Walld, and Roos 2008; Royer 2009; Sanders 2012; Figlio, Guryan, Karbownik, and Roth 2014). Aizer, Currie, Simon, and Vivier (2018) and Persico, Figlio, and Roth (2016) find that exposure to lead and Superfund sites impacts test scores and other educational outcomes, and that reductions in such exposure substantially reduces the gap in educational outcomes between disadvantaged and other children. Thus, pollution today may have inequitable effects not only on today's poor, but on the future poor as well. Indeed, it may contribute to perpetuating poverty traps.

Potential Mechanisms

Many of the studies documenting correlations among race, income, and pollution are unable to distinguish among alternative causal stories. Yet understanding the causal channels is important for two reasons. First, it helps to narrow down the locus of injustice. Is it based in actions by firms, either that are intentionally discriminatory or that have a discriminatory effect? In the underlying distribution of income? In differential patterns of participation by households in siting and permitting decisions? In enforcement decisions by governments? Second, understanding causal channels is crucial for designing policies meant to reverse the observed correlations.

Because modern econometrics has put such a heavy emphasis on causal identification, identifying the relative importance of these mechanisms may be an area where economists can best contribute to the environmental justice discussion. In this section, we consider four categories of causal mechanisms that could possibly give rise to environmental justice correlations: disproportionate siting by firms, "coming to the nuisance" on the household side, market-like coordination of the two in a process we will describe as Coasean bargaining, and discriminatory politics and/or enforcement.

Disproportionate Siting

A central focus of the environmental justice literature long has been whether, taking residential locational patterns as given, firms site (or historically have sited) polluting activity in poor neighborhoods and/or neighborhoods with people of color. Such disproportionate siting might occur for three broad reasons.

First, firms may be engaging in taste-based discrimination by incorporating into their decision-making a preference for protecting whites from pollution or indulging a malevolent preference to harm other groups (Becker 1957). Many economists, when first hearing about environmental justice concerns, assume this is what activists and researchers from other disciplines have in mind. In our experience, though, few activists or noneconomists think in these simplistic terms. Rather, they have a much more sophisticated understanding of the socioeconomic processes at work. Second, firms might site their polluting activity based on local economic conditions, which in turn are correlated in space with residential demographic patterns. For example, firms might seek access to inexpensive land, low-wage labor, or transportation networks (Wolverton 2009). These features might happen to be correlated with locations of poorer households for any number of reasons. Poorer households also might seek inexpensive land, for example, and they have lower wages almost by definition. Also, the correlations might arise indirectly from other types of discrimination. For example, industrial facilities may be attracted to locations near expressways or railroads, but those transportation routes might be located where they are because of past discriminatory transportation siting. Third, government agencies themselves make decisions that affect the location of such facilities, perhaps through the permitting process or other incentives that steer firms to such locations.

At the time of siting, firms do appear to go to areas that have a disproportionate share of people of color (Been 1997; Pastor, Sadd, and Hipp 2001; Baden and Coursey 2002). But modeling firm location as a decision variable, Wolverton (2009) finds that this pattern seems to arise more from economic factors such as land, labor, and access to transportation, rather than directly from local demographics.

Coming to the Nuisance

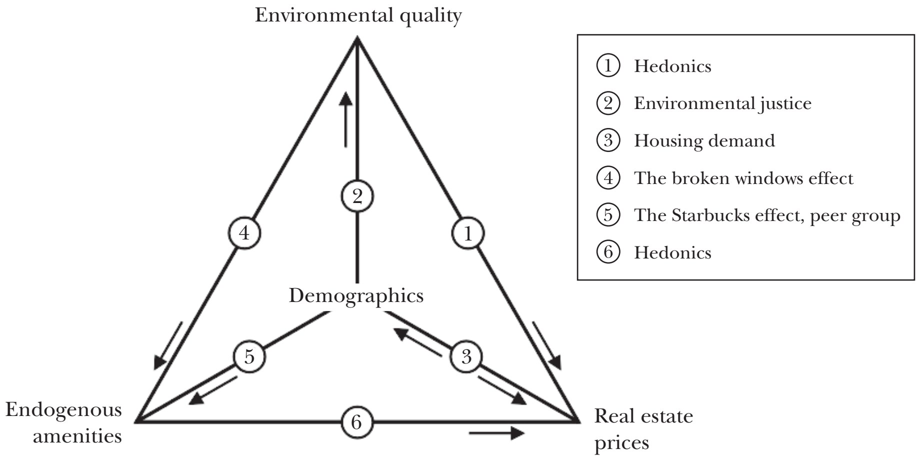
An alternative approach takes the pattern of pollution as given and considers the possibility that the households move based on their willingness to pay (and ability to pay) for a clean environment (Been 1994, 1997; Hamilton 1995). For economists, this perspective is an application of Tiebout's (1956) canonical model of residential sorting. In Tiebout's theory, households choose a location subject to a budget constraint, while taking into account desirable neighborhood amenities like a clean environment, green spaces, school quality, public safety, and access to employment centers and retail outlets. Because households prefer nicer neighborhoods, their demand for such neighborhoods is higher and, hence, ceteris paribus, so is the price of housing in those neighborhoods. Households therefore make tradeoffs between consumption and local neighborhood amenities, "voting with their feet" to reveal their willingness to pay more for public goods through higher gross-of-tax housing costs. How much a household is willing to pay for these amenities depends on its preferences and budget.

To imagine how this process works, consider a pair of neighboring communities with different levels of amenities and housing prices. A high-income household will obtain greater utility from the high-amenity community, and bid up prices there based on their willingness to pay. A lower-income household might also prefer the high-amenity community, but is not willing to pay the higher price, preferring to prioritize necessities like food and clothing. Essentially, it gets out-bid in the market for environmental quality. In this way, households "sort" by income across levels of amenities, a process also known as "stratification." Poorer households end up in more polluted areas, just as they obtain less of many of the other things money can buy. Moreover, if one demographic group (say, whites) is richer than another group throughout the distribution, then the poorer group will have more exposure to pollution on average (Banzhaf and Walsh 2013).

An initial sorting process like this may lead to additional effects on neighborhood characteristics as well, effects that could reinforce the initial sorting patterns. Figure 5 displays a pyramid of such relationships that could give rise to correlation between pollution and demographics in equilibrium (Banzhaf and McCormick 2012). Each vertex represents an outcome, and the lines connecting vertices represent relationships.

Line 2 depicts the direct relationship between environmental quality and demographics, documented in the environmental justice literature. Lines 1 and 3 show how this relationship can arise indirectly as areas with higher environmental quality have higher prices (as documented by the large "hedonics" literature), and richer people can afford higher prices as income effects shift out their demand.

Figure 5
Pyramid of Environmental Gentrification



Source: Banzhaf and McCormick (2012).

Meanwhile, if pollution signals neglect of, or disregard for, the neighborhood, polluting facilities may in this way undermine the provision of other local public goods, a kind of "broken windows" effect (Line 4). Additionally, once an initial sorting occurs because of the pollution, different demographic groups may create different neighborhood environments, based on their taste or their ability to pay for them. They may attract different types of retail (the so-called "Starbucks effect"), and richer neighborhoods may have a greater capacity than poorer neighborhoods to provide public safety, school quality, and so forth (Line 5). Such effects can further drive sorting, creating a multiplier effect (Banzhaf and Walsh 2013; O'Sullivan 2005; Sethi and Somanathan 2004). As Schelling (1969) showed many years ago, if people have even modest preferences to be with their own racial or ethnic group (homophily) for any reason, the dynamics of sorting can create "tipping patterns" such as white flight, driving further segregation. Such effects can also feed back on housing prices (Line 6).

To the extent that these Tiebout sorting processes by households are responsible for the observed correlations between demographics and pollution, there are four implications with some relevance for policy. First, the observed patterns may be "efficient"—*given the underlying distribution of resources.* That is not to say the outcome is "best" in a broad social welfare sense, but only to say that the poor may be doing the best they can with what they have. Second, to the extent that Tiebout sorting by households explains disparate exposure to pollution, it pushes back the locus of injustice from environmental inequities per se to the underlying distribution of income. In a similar vein, inequalities in the level of housing, energy consumption, and food consumption are all evidence of a deeper inequality of income and wealth. Third, if as illustrated in Line 5 of Figure 5, households sort based on homophily, or have preferences for other amenities that are shared by households like themselves, it can create a kind of "tax" on the ability to obtain a clean environment. For example, people of color who want a clean environment not only have to pay in the form of higher housing costs, but also to live in a majority-white community, for which they might perceive little benefit (Banzhaf and Walsh 2013; Ford 1994).

Fourth, cleaning up locally polluted areas may increase the demand for local housing, bidding up housing prices (Line 1), a phenomenon known as "environmental gentrification" (Sieg, Smith, Banzhaf, and Walsh 2004; Banzhaf and McCormick 2012). For example, cleanup of Superfund sites (Gamper-Rabindran and Timmins 2013), brownfields (Haninger, Ma, and Timmings 2017), or hazardous waste sites more generally (Taylor, Phaneuf, and Li 2016) have been estimated to yield housing price increases of 5 to 15 percent. If high-income households bid up housing prices by their own willingness to pay, and if that willingness to pay exceeds that of the poor, the perverse result is that cleaning up pollution in a poor neighborhood can harm the poor, as prices increase by more than their willingness to pay. Homeowners, of course, also have a more valuable asset. But the poor are mostly renters, and renters only face higher rents, while landlords reap the gains. In this way, environmental justice considerations are not only wrapped up in the underlying distribution of income, but also potentially in historical policies such as "red-lining" (the practice of making mortgages less available to those living within certain neighborhoods) that have exacerbated disparities in homeownership (Aaronson, Hartley, and Mazumder 2017).

Empirical researchers have tried to examine the extent to which demographic factors in an area shift after either siting or closure/exit of polluting facilities, using difference-in-differences or similar methodologies. These studies have yielded mixed findings.[6] Many of them have approached the problem as a chicken-or-the-egg question: Which came first, the siting of facilities in a poor, non-white neighborhood, or the sorting of such households near pollution? However, this problem has proven difficult to unscramble. There are at least four reasons why *changes* in demographics may not appear to be correlated with *changes* in pollution, even when cross-sectional correlations truly are driven by Tiebout sorting.

First, comparisons of the way different locations have evolved over time are complicated by general equilibrium effects in space. For example, imagine that pollution is cleaned up in a predominantly poor community, triggering in-migration. If the in-migrants are the poorest members of the comparison community, then *both* communities can become richer on average, making the prediction for differences-in-differences ambiguous, except for large changes (Banzhaf and Walsh 2008). The story is even more complicated for demographic groups (like racial

[6] Evidence in favor of post-siting (or post-clean-up) sorting can be found in Baden and Coursey (2002), Banzhaf and Walsh (2008), Depro, Timmins, and O'Neil (2015), Gamper-Rabindran and Timmins (2011), Lambert and Boerner (1997), Oakes, Anderton, and Anderson (1996), and Wolverton (2009). Evidence against can be found in Been (1997), Cameron, Crawford, and McConnaha (2012), Cameron and McConnaha (2006), Eckerd (2011), Greenstone and Gallagher (2008), Messer et al. (2006), and Pastor, Sadd, and Hipp (2001).

groups), because the effects additionally depend on the relative density of each group at the marginal level of income where adjustments are occurring (Banzhaf and Walsh 2013).

Second, Depro, Timmins, and O'Neil (2015) show that there is an even more fundamental problem: without additional structure, individual sorting behavior with respect to pollution is not even identified from aggregate population changes. They construct examples illustrating that even when preferences for environmental quality versus other consumption leads people of color to differentially come to a nuisance, it does not necessarily follow that the percentage of residents who are of color will increase more in the polluted community than elsewhere. The problem comes from using aggregate data without observing the underlying substitution patterns implied by the specific population flows in the micro data.

Third, more generally, dynamic models often introduce the possibility of some hysteresis, or stickiness, in community compositions over time. For example, suppose an area initially is polluted, households sort on this pollution, and then the area is cleaned up. If perceptions are sticky, so that people believe the area is still dirty, or if some "stigma" has become associated with the original state (as in the broken windows effect), the initial sorting may not be reversed (Cameron and McConnaha 2006; Messer, Shultze, Hackett, Cameron, and McClelland 2006).

Finally, the multiplier effects discussed above also can create hysteresis. Changes in local amenities resulting from demographic sorting will themselves have feedbacks on housing prices, which induce further changes in sociodemographics. Consequently, even if the nuisance is eventually cleaned-up, housing prices may not bounce back because of these other changes, which themselves occurred as a result of Tiebout sorting (a sequence of Lines 5, 6, and 3 in Figure 5). Indeed, Banzhaf and Walsh (2013) show that if such effects become more salient after cleaning up pollution—because there is less reason to sort on environmental quality once it is cleaned up—then the reduced-form correlation between pollution and demographics can become *stronger* after cleanup, as racial differences increase and pollution differences decrease between communities. Consequently, scholars looking for such a reversal may fail to find it in the difference-in-differences.

Although the research literature speaking to coming-to-the-nuisance effects is large and growing, our view is that it still has not come to grips with many of these shortcomings. As a consequence, the jury is still out on the empirical relevance of this hypothesis. Depro, Timmins, and O'Neil (2015) offer one promising path forward—modeling substitution patterns and unobserved heterogeneity with a structural model in order to uncover heterogeneous willingness to pay for environmental patterns and, hence, sorting patterns. Future work might make more use of micro data describing individual moves, which would allow weaker modeling assumptions.

Coasean Bargaining

Firms have preferences over where to locate their industrial facilities and a willingness to pay to locate at a certain place. Households have a tolerance for pollution and some willingness to accept compensation for industrial activity nearby. Whereas the previous two subsections take each of these perspectives in isolation, a Coasean perspective sees (the potential for) transactions between the two sides.

The Coase theorem holds that, under well-defined property rights and in the absence of transaction costs, it does not matter who holds the property rights to the use of the environment because negotiation and market transactions will ensure the same, efficient use of resources (Coase 1960). Through negotiation, the right to pollute (or to be spared pollution) will end up in the hands of the individuals or firms who value it most, and all parties will be appropriately compensated for any nuisance or foregone profits they consequently bear. However, the distribution of payments in this structure will depend on the initial allocation of property.

Consider a facility that emits pollution into the surrounding environment at zero private cost incurred by the facility. Each additional unit of pollution emitted creates a benefit to the facility in terms of not having to use an expensive abatement technology or not having to forego production. These marginal benefits to the facility from emitting pollution are declining and the facility will choose to generate additional units of pollution up to the point where marginal benefits of emitting pollution fall to zero. Suppose that local residents hold the relevant property rights, in the sense that they can veto polluting activities or accept them. Even if legislation does not explicitly recognize this right, local residents may be able to assert it through tort law, zoning laws, holding up permitting processes, political protest, and so forth. In the absence of any sort of compensation, local residents would prefer that the facility release no emissions. From a Coasean perspective, there is an opportunity for trade, in which residents of the community agree to some level of pollution in exchange for compensation. Such payments may be cash transfers, or they may take the form of local jobs, investments in parks and community centers, and so forth.

In this situation, the exact amount of the payment the firm needs to make would be determined in some fashion between the two parties, according to their relative bargaining power. One aspect of this negotiation is that polluters have an incentive to locate where the local residents are willing to accept relatively low compensation to offset accepting a degree of pollution; also, a community that requires relatively low compensation for accepting pollution will be compatible with a higher efficient level of pollution. For example, their willingness-to-accept compensation for pollution will tend to be lower in remote locations with fewer people, so that total injuries are lower. Alternatively, those with lower income levels may also be willing to accept lower levels of compensation for injuries. In either case, Coasean bargaining theory would treat this incentive as one leading to economic efficiency. However, this latter incentive might also give rise to environmental justice correlations (Hamilton 1995). It is likely to be poorer households who have a lower willingness to accept compensation, perhaps because they have a high marginal utility of income and prioritize consumption of other important goods.

As with the Tiebout mechanism, the model of Coasean bargaining suggests that the observed distribution of pollution is efficient—given the distribution of income. Likewise, it also shifts the locus of injustice back to inequality in the underlying distribution of income and wealth. However, in the Coasean case, the environmental resource is a valuable asset, and its allocation represents part of the distribution of wealth.

Combining Coasean insights with the insights of the environmental justice movement, there would be important justice arguments for allocating the right to the environment to local communities. In this case, local communities could then keep the right to be free of polluting facilities, or negotiate with polluters, as they saw fit. If such communities have full information and full power to bargain (admittedly big "ifs"), they cannot be worse off if they accept compensation and allow polluting facilities to operate. This observation highlights one potential area of tension in the understanding of environmental justice. While in many cases, a focus on equity of exposure to pollution (a kind of distributive justice) and a focus on the ability to participate in decision-making (procedural justice) run together, they do not always. Full environmental justice entails sovereignty over environmental decisions, and thus the right to accept polluting firms as well as to reject them (Foster 1998).

A Coasean bargaining scenario raises the obvious question of why, then, there is an environmental justice movement protesting siting that leads to local pollution. Presumably, disadvantaged groups are bearing the brunt of pollution exposure but do not feel they are receiving the compensating benefits of such Coasean bargains. Why not? One possibility, of course, is that local communities do not have the property rights to the environment, so that firms can locate where they wish, perhaps with discriminatory effect. Allowing for more nuance, it may be that property rights are ambiguous and are left open to being claimed through political action, or being exploited through channels such as zoning and permitting processes. To some extent, the environmental justice movement might be interpreted as an effort to claim rights. Alternatively, it might be interpreted as a protest of the extra difficulty environmental justice communities have to go through in claiming such rights. Such communities may be limited by, for example, less access to the corridors of power, less formal education, language barriers, and other such disadvantages (Hamilton 1995). In addition, communities facing environmental justice concerns may have difficulties overcoming the free rider problem on their side of the negotiation: whereas the benefits of polluting are a concentrated interest for one firm, the costs of polluting are dispersed among all residents of a jurisdiction. As a consequence, communities facing environmental justice concerns, when in negotiations, may end up systematically with a small share of the Coasean surplus. Indeed, firms might systematically aim to locate in communities which will be in a weaker bargaining position.

Stepping back, we might ask what it even means to allocate rights to local communities, and who speaks for the community in negotiations. Whether the actual decisionmakers at the local level are local government officials or community organizations, it will commonly be true that those bargaining on behalf of victims are not actually bearing the costs of the pollution—and thus the negotiation may lead to more pollution and less compensation than if the victims bargained for themselves.

Such themes seem to have been illustrated by the case of Kettleman City, California, described in Cole and Foster (2001). In 1988, a waste management firm proposed building a toxic waste incinerator at a nearby dump site. Located in the San Joaquin Valley, Kettleman City was 90 percent Hispanic, with 40 percent of residents speaking no English. Through inadequate provision of public notice, the begrudging provision of translators at public meetings, and the scheduling of those meetings in difficult-to-reach locations, it was clear that information asymmetries were part of a strategy to inhibit local participation. Despite vigorous protests from the residents of Kettleman City, Kings County initially approved the deal. The county was to receive $7 million annually from the deal, but these benefits were spread over a 1,400 square mile rural county, with a very different demographic, while the environmental injuries were concentrated in Kettleman City.

The Kettleman City example demonstrates how political economy problems can overcome Coasean forces even at the county level. Such forces may be even stronger at the state level. The Cerrell Report (Cerrell Associates 1984), a consulting report requested by the state of California Waste Management Board, provides an infamous example of an effort to direct the siting of polluting facilities towards communities that would be ineffective bargainers. The report identified characteristics of local communities that would not protest the location of waste sites in their area—in particular, people without a college education, the poor, Catholics, and those "not involved in voluntary associations."

More systematically, Timmins, and Vissing (2017) examine the content of leases signed between shale gas operators and households in Tarrant County, Texas, for the rights to extract natural gas. The terms of these leases dictate both payments in the form of royalty compensation and protective clauses designed to reduce health and environmental risks from the extraction process. After conditioning on income, Vissing and Timmins find that race and, interestingly, English-speaking are correlated with lease terms (like protective clauses) and royalty compensation.

There are other cases in which we see some evidence of Coasean logic at work, in the sense of the comparative analysis of transactions costs. For example, Coasean compensation appears to take place in the form of host fees collected by neighborhoods near landfills. Jenkins, Maguire, and Morgan (2004) find that citizen participation in host fee negotiations leads to greater host compensation. Similarly, Hamilton (1993, 1995) finds that communities better able to organize politically (as proxied by higher voter turnout) are less likely to see local firms expand their processing of hazardous wastes (see also Brooks and Sethi 1997; Arora and Cason 1999).

Political Economy and Government

Governments can affect the distribution of pollution in a number of ways, including through legislation, bureaucratic monitoring and enforcement patterns, and court enforcement patterns. 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. They may make decisions based on technical factors (like size of operating facility, hazardousness of processed materials, potential risks to surrounding neighborhood), on polluter factors (like polluter's ability to pay, polluter's violation history, polluter's negotiation/bargaining power), and on the weight they give to interest groups that may "capture" the regulatory process. This raises the possibility that regulators could be a source of inequitable exposure to environmental nuisances. Households with the highest willingness to pay for avoiding pollution, combined with the greatest ease and ability to influence government, may exert the most pressure on government agencies (Becker 1983). Thus, as with Coasean bargaining, differences in the ability to organize, be heard, or be pivotal to government officials can drive different degrees of influence.

In an early study, Lavelle and Coyle (1992) concluded that polluters accused of violating environmental regulations faced lower enforcement penalties if they were in areas with more people of color. They also found that, in such areas, cleanup times were longer and cleanup solutions were less stringent. Viscusi and Hamilton (1999) re-examined remediation activities, focusing on the choice of post-cleanup standards. They found, perhaps surprisingly, that regulators impose *stricter* risk targets in areas with more people of color. The same is also true (less surprisingly) in areas with greater potential for collective action. Income and proportion non-white do not appear to affect the cost per cancer case avoided, but voter turnout (a proxy for collective action) does. More recently, Gray and Shadbegian (2004) and Shadbegian and Gray (2012) have studied the determinants of regulatory stringency in communities near polluting facilities, with a focus on the application of penalties and the frequency of inspections. They again find that measures of the potential for collective action are important determinants of enforcement activities, but also that race does not have an independent effect and that the effect of income is mixed.

We conclude that there is evidence that regulatory actions are at least correlated with the political power of local communities. Interestingly, this finding is similar to that used in the literature to evaluate the extent of Coasean processes. This similarity highlights the important connection between Coasean processes and political economy, as both are tied up in property rights and the enforcement of those rights.

Discussion and Conclusion

In 1993, some ten years after it was sited, the Warren County landfill in North Carolina was found to be leaking PCBs. Eventually, 81,500 tons of contaminated soil were excavated and burned at a cost of $18 million, seemingly justifying the initial protests over the decision. Moreover, as the more recent case of lead contamination in the water of Flint, Michigan, indicates, controversies over environmental justice are still with us. Like Warren County, Flint is disproportionately poor and African American. And also like Warren County, it was higher levels of government that made decisions affecting local populations, populations that felt they did not have an adequate voice.

Cases like these highlight a first "no-brainer" policy response to environmental justice concerns: giving local populations a seat at the table when making decisions that affect the local environment. In some cases, this may mean devolving decisions to more-local governments. In others, it may mean incorporating local comments into state-level or national regulatory reviews. As noted previously, the policy of the Environmental Protection Agency calls for "meaningful involvement" of all people.

Having a seat at the table can help environmental justice communities in other contexts as well. In particular, if outcomes are the result of Coasean bargains, then policies should be structured to assure that disadvantaged communities can bargain more effectively based on their preferences: for example, access to legal expertise and pollution disclosure policies can increase access to information about hazards and legal remedies. Here, environmental justice advocates can play an important role, by providing services that effectively reduce transactions costs for local residents and that level the playing field. Having such a voice might also minimize gentrification effects, if local residents propose new uses for previously contaminated lands that better fit the existing character of the community (NEJAC 2006).

Second, insofar as disproportionate exposure arises out of firm choices to locate in areas with people of color (for whatever reason), then such patterns affect the distribution of real wealth. Accordingly, environmental policies that target pollution directly may have a "double dividend" in being progressive as well as (potentially) efficiency enhancing, as recently argued by Bento, Freedman, and Lang (2015).

Third, people-based investments that target income inequality may be more fruitful than targeting environmental correlations, especially if sorting is the predominant force underlying environmental justice correlations. Such sorting would place the ultimate source of the correlations in the income distribution; it also implies that attempts to reverse environmental justice correlations may be accompanied by gentrification effects. Of course, this suggestion begs the question of how to reduce inequality. In a narrow sense, one might focus on ways for low-income renters and owners to have a wider range of affordable housing options, essentially giving them a property right in environmental improvements. As a result, they would be less likely to face a tradeoff between lower housing costs and exposure to pollution. One can also imagine a range of other compensatory benefits, like greater support for health care for pregnant women and programs to support the development of newborns and very young children. In general, the fact of disparate environmental effects on those with low socioeconomic status strengthens the arguments for redistribution to these groups in other forms.

The last two points raise a more general issue about the evaluation across income groups of policies that create environmental benefits and costs. Given the current distribution of pollution exposure, the direct effects of environmental improvements will generally be progressive in the sense that the improved quality of life and health should be enjoyed especially by those of lower socioeconomic status. But on the other side, the indirect effects of environmental improvement on housing prices (gentrification) and energy prices may be especially burdensome to the poor. Both effects could be better incorporated into regulatory decision-making. Current practice of the Environmental Protection Agency is to incorporate environmental justice into rulemaking; focus (though not exclusively) on assessing the distribution of health risks and benefits; and use a constant willingness-to-pay to aggregate the benefits for all demographic groups (US EPA 2014, 2016).

However, when policies have differential costs as well as benefits, such a practice can distort benefit–cost tests. Indeed, in theory, a policy that harms everybody could pass benefit–cost tests with this practice. Suppose, for example, that the rich are willing to pay $8 million per statistical life saved, and the poor $4 million (because, having greater unmet needs, their opportunity cost of money is higher). Suppose there are equal numbers of rich and poor. Suppose finally that a policy would cost the poor $5 million per statistical life saved (in higher prices) and cost the rich a very small amount but save no lives among the rich. Using an average value of life of $6 million, the policy would pass a benefit-cost test. But everybody is made worse off by the policy. Given a concern that heterogeneous willingness-to-pay may favor higher-income groups, one could combine heterogeneous willingness-to-pay with distributional weights based on a social welfare function while making more effort to include indirect, general-equilibrium effects. This could give regulators a systematic way to implement environmental justice concerns while still giving people sovereignty in the sense of respecting their individual preferences (Adler 2016; Banzhaf 2011).

Key to this policy discussion is that any specific prescription is contingent upon *how* inequities arise. Tackling the remaining uncertainty about the relative importance of such causes is critical if we hope to address environmental injustice at a fundamental level. Armed with models of residential location, firm entry/siting decisions, and government decision-making, economists today are in a unique position to contribute to the discussion of "why" environmental injustice arises and to devise appropriate policy solutions.

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