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The Unintended Significance of Race: Environmental Racial Inequality in Detroit*

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Abstract

This article addresses shortcomings in the literature on environmental inequality by (a) setting forth and testing four models of environmental inequality and (b) explicitly linking environmental inequality research to spatial mismatch theory and to the debate on the declining significance of race. The explanatory models ask whether the distribution of blacks and whites around environmental hazards is the result of black/white income inequality, racist siting practices, or residential segregation. The models are tested using manufacturing facility and census data from the Detroit metropolitan area. It turns out that the distribution of blacks and whites around this region's polluting manufacturing facilities is largely the product of residential segregation which, paradoxically, has reduced black proximity to manufacturing facility pollution.

Over the last 15 years, an expanding body of research has sought to ascertain whether environmental hazards are distributed inequitably according to race and income. In particular, researchers want to know whether minorities, the poor, and the working class are more likely than whites and wealthier individuals to live near environmental hazards. Researchers are interested in these questions because of the possible health impacts of exposure to environmental pollutants and because survey data suggest that regardless of race or income, people do not want to live near hazardous waste sites or polluting industrial facilities (Mohai and Bryant 1998).

Despite increased levels of concern about environmental inequality, mainstream sociology has paid relatively little attention to this topic. This is unfortunate in a couple of respects. On the one hand, the study of environmental inequality provides sociologists with an opportunity to introduce sociological thinking to a field of study with important public policy and health ramifications. On the other hand, environmental inequality research has much to teach sociologists about the relationship between race and class and about the role racism plays in shaping social outcomes.

For example, several environmental inequality studies have found environmental hazards to be distributed *equitably* according to race in areas where they are distributed *inequitably* according to income, despite the fact that minorities generally earn significantly less than whites (Anderton et al. 1994a; Oakes, Anderton, and Anderson 1996; Yandle and Burton

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[8] I include the residential stability variables because residential stability has been shown to be positively associated with neighborhood collective efficacy (Sampson, Morenoff, and Earls 1999) which, in turn, is likely to be negatively associated with facility presence change. Neighborhood efficacy and facility presence change are likely to be negatively associated with one another because efficacious neighborhoods are more likely than other neighborhoods to organize themselves successfully against unwanted land uses.

1996). But if income is negatively associated with environmental hazard presence and minorities earn less than whites, then minority presence should be positively associated with hazard presence. That this is not always the case suggests that racial status sometimes *decreases* minority representation in environmentally hazardous neighborhoods below what we would expect based on income alone. This raises interesting and important theoretical questions. Are there situations in which racial status separates minorities from socially undesirable goods such as pollution? More specifically, can racism in one institutional arena (for example, the housing market) weaken racial inequality in another arena (the environment)?

In order to answer these questions, I use 1970, 1980, and 1990 data to track the flow of social groups and polluting manufacturing facilities through the Detroit metropolitan area, a region where environmental racial inequality is relatively weak despite the fact that black/white income inequality and income-based environmental inequality are relatively strong. I use census and manufacturing facility data to test four models of environmental inequality that make predictions about the determinants of manufacturing facility siting decisions and the impact that manufacturing facility presence has on neighborhood demographics. Taken collectively, the models ask whether the distribution of blacks and whites around polluting manufacturing facilities is the result of black/white income inequality, racist siting practices, or the biased operation of the housing market.

As we shall see, the distribution of blacks and whites around Detroit's polluting manufacturing facilities is not the result of black/white income inequality or racist siting practices. Instead, it is largely the product of residential segregation which, paradoxically, has reduced black proximity to manufacturing facility pollution. Thus, it turns out that racial status and racism play an important role in shaping environmental inequality in the Detroit metropolitan area, but they operate indirectly through the housing market, and their effect has been to separate blacks from manufacturing facility pollution.

Environmental Inequality

Environmental inequality is a relatively new concept that gained national attention in the late 1980s and early 1990s due to the efforts of grassroots environmental justice activists and professional researchers. Calling into question the mainstream environmental movement's assumption that environmental degradation affects everyone equally, environmental justice activists and researchers argue, among other things, that the poor, the working class, and people of color are disproportionately burdened by environmental hazards.

This assertion has become the subject of a growing body of academic research (Anderton et al. 1994a, b; Bowen 2002; Bowen et al. 1995; Brown, Ciambrone, and Hunter 1997; Hunter 1998; Lester, Allen, and Hill 2001; Mohai and Bryant 1992; Morello-Frosch, Pastor, and Sadd 2001; Pastor, Sadd, and Hipp 2001; Ringquist 2000; Sadd et al. 1999; Szasz and Meuser 1997; Yandle and Burton 1996). An important debate in this new field centers on the relative importance of race and income in predicting who lives near environmental hazards (Mohai and Bryant 1992). The debate takes the following form: Are minorities more likely than whites to live near environmental hazards, and if so, is it because of their racial status or because minorities tend to have lower incomes than whites? While this debate has generated some important insights, it has also been plagued by several critical shortcomings, three of which are discussed here.

First, because researchers have been preoccupied with determining the predictive power of race and income at a single point in time, they have devoted little attention to studying the historical processes that have given rise to environmental inequality (exceptions include Krieg 1995; Oakes, Anderton, and Anderson 1996; Pastor, Sadd and Hipp 2001). Second, hypotheses about the determinants of environmental inequality have not been organized into coherent models that can be formally tested. Third, environmental justice research is not theoretically grounded. For example, although many environmental inequality researchers study manufacturing facility pollution, few, if any, discuss deindustrialization or class conflict, factors that are likely to play an important role in shaping environmental inequality. Similarly, few links have been made between environmental inequality research, the *declining significance of race* debate, and spatial mismatch theory, despite the fact that the debate on the declining significance of race focuses closely on the relative importance of race and income in explaining racial inequality and the fact that spatial mismatch theory hypothesizes a spatial disjuncture between manufacturing facilities and poor, urban black neighborhoods.

This article advances our understanding of environmental inequality by (a) setting forth four models of environmental inequality, (b) using these models to isolate the historical determinants of environmental inequality in the Detroit metropolitan area, and (c) explicitly linking environmental inequality research to the declining significance of race debate and spatial mismatch theory.

Spatial Mismatch Theory and Environmental Inequality

Spatial mismatch theory highlights the manner in which industrial investment patterns since World War II have differentially affected black and white workers. According to spatial mismatch theorists, industrial flight from the urban core to the suburbs and rural areas after World War II hurt black workers more than white workers because residential segregation prevented blacks from leaving the central city, creating a spatial mismatch between the location of black neighborhoods and the location of manufacturing jobs, and because blacks relied more heavily on manufacturing employment than did whites (Darden et al. 1987; Farley, Danziger, and Holzer 2000; Frey 1984, 1987; Ilhanfeldt and Sjoquist 1998; Kain 1968; Kasarda 1995; Massey and Denton 1993; Mouw 2000; Sugrue 1996; Wilson 1987).

But if residential segregation and industrial flight have created a spatial mismatch between the location of black neighborhoods and the location of manufacturing jobs, it stands to reason that these factors have also created a spatial mismatch between black neighborhoods and manufacturing facility pollution. Thus, if spatial mismatch theory is correct, we would expect the association between neighborhood racial composition and manufacturing facility pollution levels to be weak, nonexistent, or biased against whites, an expectation that clearly contradicts that put forth by environmental inequality researchers.

The Declining Significance of Race Debate

The declining significance of race debate arose in response to Wilson's (1978) claim that the importance of race has declined in the modern industrial period. According to Wilson, prior to World War II there was little differentiation among blacks in the labor market. Since then, however, labor market discrimination has decreased and occupational differentiation among blacks has increased, so much so that the life chances and experiences of blacks now depend much more on their class position than their racial status. The increased residential mobility of middle-class blacks since the civil rights era has reinforced the salience of class by allowing middle-class blacks to flee urban ghettos, thereby isolating poor blacks. As a result, the life experiences and opportunities of middle-class blacks are very similar, if not identical, to those of middle-class whites and increasingly different from those of poor and working-class blacks (Wilson 1987).

Wilson's thesis has been critiqued by many researchers (Collins 1997; Feagin and Sikes 1994; Sugrue 1996; Waldinger 1996). But the most prominent critique of his thesis is probably that put forth by Massey and Denton (1993), who document in great detail the extreme and unique degree to which blacks historically have been and currently are segregated from whites. They argue that in the post–civil rights era, residential segregation and high black poverty rates have combined to concentrate poverty in black neighborhoods at much higher rates than in white neighborhoods. Segregation has also isolated poor, urban blacks from good schools, other social groups, and the social and occupational networks that help individuals achieve economic success. Finally, segregation has made it difficult for middle-class blacks to distance themselves spatially from the poor and working class and prevented them from residing in the same neighborhoods as middle-class whites.

In taking this position, Massey and Denton are arguing not only that racism and racial status continue to play a decisive role in shaping blacks' lives but also that residential segregation consistently aggravates racial inequality through its impact on blacks' social and political networks, neighborhood institutions, educational opportunities, and residential mobility. Thus, the debate between Wilson and his critics revolves around two issues. First, is racial inequality caused by racial discrimination or is it merely a byproduct of class inequality? And second, does racial inequality in specific institutional arenas arise from intentionally racist acts in those arenas or from the racially biased operation of other institutions?

Explanatory Models

In order to understand what role, if any, racial status and racism play in determining who lives near polluting manufacturing facilities, I set forth and test four models of environmental inequality: an economic model, a racist intent model, a simple segregation model, and a racial succession model. The first three models are drawn from the literature on environmental inequality, while the fourth is drawn from the broader sociological literature on race and urban development.

Before describing the models, two points must be made. First, although each of the four models provides a logically distinct explanation of environmental inequality and although predictions made by one model often contradict predictions made by the other models, the models are not entirely exclusive. For example, as we shall see, the *economic model* predicts that industrial facilities will be sited in low-income neighborhoods, while the *racial succession model* predicts that blacks will be drawn into neighborhoods immediately adjacent to already-black neighborhoods. Although it is certainly possible that only one of these predictions will be supported by the evidence, it is also possible that both (or neither) will be supported by the evidence.

As we shall also see, the models focus on different aspects of the environmental inequality formation process. (This term is borrowed from Pellow 2000.) For example, one explanatory model focuses solely on siting decisions, and two explanatory models focus solely on demographic changes in facility neighborhoods. Thus, it is quite possible that more than one model will be supported by the evidence presented below.

Second, the four models make predictions about individual and firm-level behavior and the aggregate, neighborhood-level consequences of these predicted behaviors. For example, the economic model makes predictions about firm-level siting decisions and the neighborhood-level consequences of these decisions, and the racial succession model makes predictions about the housing choices of individual whites and the neighborhood-level consequences of these choices. However, because appropriate data are not available to test the individual and firm-level predictions of the models, I test the neighborhood-level predictions instead.

AN ECONOMIC MODEL OF ENVIRONMENTAL INEQUALITY

The economic model makes income-based predictions about industrial siting decisions and the impact of facility location on neighborhood demographics.[1] Specifically, the model holds that industrial facilities tend to be sited in low-income neighborhoods because property values tend to be low in these neighborhoods and firms attempt to site facilities where property values are low (Mohai and Bryant 1992). The model predicts, therefore, that *neighborhood* incomes and property values should be negatively associated with the number of new facilities in a neighborhood, the total number of facilities in a neighborhood, and changes over time in the number of facilities in a neighborhood. Moreover, because blacks tend to have lower incomes than whites, blacks should be more likely than whites to live in facility neighborhoods and in neighborhoods with new facilities. As a result, the percentage of blacks in a neighborhood should be positively associated with the number of facilities in a neighborhood and changes over time in the number of facilities in a neighborhood. However, blacks and whites with the same incomes should be equally represented in facility neighborhoods and in neighborhoods with new facilities.

The model goes on to note that once industrial facilities are sited in a neighborhood, its property values, rental values, and environmental integrity begin to decline, leading wealthier individuals to flee the neighborhood and poorer ones to move in (Hamilton 1995; Mohai and Bryant 1992). Therefore, income levels in neighborhoods surrounding polluting facilities should decline over time relative to overall area incomes, and blacks should be drawn disproportionately into facility neighborhoods because of their relatively low incomes. Put more formally, the model predicts that neighborhood property values and rents should be positively associated with changes over time in neighborhood income levels and negatively associated with changes over time in the percentage of blacks in a tract. It also predicts that facility presence should be negatively associated with changes over time in neighborhood income levels and positively associated with changes over time in the percentage of blacks in a neighborhood.

Table 1 summarizes these predictions in terms of the independent and dependent variable concepts embedded in each of them. The table is divided into four sections, one for each explanatory model under consideration, and lists the dependent and independent variable concepts embedded in each prediction as well as the expected relationship between them. Variable concepts are listed rather than the actual indicators employed below in order to keep my theoretical and methodological discussions separate. Later in the article, I include a table (Table 2) that organizes these predictions according to the dependent variables used to test them and that lists the indicators used in my regression models. Tables 1 and 2 in combination help clarify how I translate the explanatory model predictions discussed in this section into the regression models I estimate below.

A RACIST INTENT MODEL OF ENVIRONMENTAL INEQUALITY

The racist intent model focuses solely on siting decisions. According to the model, environmental hazards are intentionally placed in minority neighborhoods because decision makers (politicians, government bureaucrats, and businessmen) and their constituents are racially prejudiced. Thus, the model holds that the percentage of minorities in a neighborhood should be positively associated with the number of new facilities in a neighborhood, the total number of facilities in a neighborhood, and changes over time in the number of facilities in a neighborhood (see Table 1; Been 1994; Hamilton 1995).

[1]Throughout this article, siting refers to the placement of new manufacturing facilities in a neighborhood, while facility location refers to the presence of already-existing manufacturing facilities in a neighborhood.

A SIMPLE SEGREGATION MODEL OF ENVIRONMENTAL INEQUALITY

The simple segregation model focuses on the racial impact of facility location on demographic change. According to the model, residential segregation helps produce environmental racial inequality because whites have greater residential choice than blacks and are therefore better able than blacks to flee environmentally hazardous neighborhoods. Due to their relatively limited residential options, blacks are also more likely than whites to move into environmentally hazardous neighborhoods (Bullard 1993; Godsil 1991; Mohai and Bryant 1992). Thus, the model predicts that blacks will be drawn disproportionately into facility neighborhoods and that whites will be drawn disproportionately away from such neighborhoods. As a result, facility presence should be positively associated with changes over time in the percentage of blacks in a neighborhood (see Table 1).

A RACIAL SUCCESSION MODEL OF ENVIRONMENTAL INEQUALITY

According to the racial succession model, facility location has relatively little impact on neighborhood racial change. Instead, the distribution of racial groups around manufacturing facilities is believed to be an outcome of general processes of demographic change and racial succession that apply to urban areas as a whole. Racial succession can be defined as " … the replacement of whites by nonwhites within the boundaries of a given neighborhood" (White 1984:165). In this model the proximity of white neighborhoods to black neighborhoods is seen as the prime determinant of racial succession.

Specifically, the model predicts that racial succession is most likely to occur in white neighborhoods that border black neighborhoods. This is because racial succession tends to occur, according to the model, when panicked whites flee their homes in the belief that their neighborhoods are about to be "overrun" by black settlers, thereby opening up their neighborhoods for black settlement. Since white panic is likely to be greatest and is easiest to produce in white neighborhoods that are adjacent to primarily black neighborhoods, these are the neighborhoods where the model predicts racial succession is most likely to occur (Massey and Denton 1993; Sugrue 1996). The result is (a) the persistence of black-white residential segregation and (b) the expansion of black neighborhoods and ghettos at their edges, with blacks moving into manufacturing neighborhoods and corridors solely because of the ghetto's overall expansion.

Thus, the racial succession model holds that residential segregation *prevents* blacks from being drawn disproportionately into manufacturing neighborhoods and corridors by channeling racial succession into neighborhoods immediately adjacent to the black ghetto regardless of whether or not those neighborhoods house manufacturing facilities. This, in turn, reduces black proximity to polluting manufacturing facilities below what we might otherwise expect.

Put more formally, the racial succession model predicts that changes over time in the percentage of blacks in a tract should be greater in white neighborhoods that are adjacent to black neighborhoods than in white neighborhoods that are not adjacent to black neighborhoods. Thus, neighborhood adjacency should be positively associated with changes over time in the percentage of blacks in a tract. Finally, facility presence should *not* be positively associated with changes over time in the percentage of blacks in a tract.

Data

I obtained demographic data for the Detroit metropolitan area from the 1970, 1980, and 1990 U.S. Census and data for manufacturing facilities from the 1970, 1980, and 1990 Michigan manufacturers directories (Manufacturer Publishing Co. 1970; Pick Publications 1980, 1990). Researchers who study manufacturing facility pollution normally use the

Environmental Protection Agency's (EPA) Toxic Release Inventory (TRI), which records the number of pounds of toxic chemicals released into the environment each year by individual manufacturing facilities. However, because the TRI has only been available since 1987, it cannot be used to evaluate historical hypotheses. Michigan manufacturers directories, which list the names, addresses, and standard industrial classification codes of manufacturing facilities throughout the state, do not have this limitation, so I use them instead.

In order to ensure that the manufacturing facilities included in this study are among the most hazardous in the region, I restricted the study to facilities in four highly polluting industrial sectors: transportation equipment, chemicals, primary metals, and fabricated metal products. These industries are well represented both currently and historically in Detroit's industrial economy, and according to the TRI were the four most highly polluting industrial sectors in the Detroit metropolitan area in 1992, responsible for approximately 99% of the region's TRI emissions that year.[2]

One potential problem with using data on manufacturing facility location rather than data on manufacturing facility pollution to create environmental hazard proximity indicators is that manufacturing facilities do not all produce the same amount of pollution. Moreover, older facilities, which are more likely to be located in inner-city Detroit than in Detroit' suburbs, may produce more pollution than newer facilities, which are more likely to be located in the suburbs. However, when I correlate 1990 manufacturing facility *pollution* indicators with the demographic variables used in this study (results not shown here), I obtain results almost identical to those I get when I correlate these demographic variables with the facility presence indicators used in this study (results for these latter correlations are shown in Table 3a). Moreover, I am not alone in using facility proximity (rather than pollution proximity) to measure environmental inequality. Many researchers have done so (for examples, see Anderton et al. 1994a, b; Mohai and Bryant 1992; Oakes, Anderton, and Anderson 1996; Szasz and Meuser 1997).[3]

Study Area

The Detroit metropolitan area is defined here as the city of Detroit and the cities and townships immediately surrounding Detroit. I use this study area definition rather than the six-county definition currently employed by the U.S. Census Bureau because this article is part of a broader study of Detroit that uses tract-level census data and digital census tract maps going back to 1940. Since the Detroit metropolitan area was much smaller in 1940 and 1970 than it was in 1990, and because of the great difficulties inherent in creating usable digital tract maps prior to 1980 and matching census tract observations over time, it was necessary to restrict the study area as described above.

One possible objection to restricting the study area in this way is that in doing so I have limited variation in the data by restricting the study to that part of the six-county region with extremely high minority concentrations. However, in 1990 the study area population was still majority white (54% white, 43% black), and in 1970 more than half of all Detroit city residents were white, while virtually none of the suburban population was black. Thus, there

[2]The geographic distribution of 1992 TRI facilities (all manufacturing sectors included) and facilities in the 1970, 1980, and 1990 four sector database is extremely similar, suggesting that the facility and TRI databases capture a common phenomenon. (Facility and TRI maps are available upon request).

[3]Another potential problem with the data is that the factors shaping environmental inequality may vary across hazards, making it impossible to generalize the findings reported here to other hazards. The only way to determine whether these factors do vary is to study multiple hazards at the same time or conduct a series of studies, each with its own hazard indicator. Because the former option is not practical, this study focuses on a single, commonly studied environmental hazard, polluting manufacturing facilities.

is considerable racial variation in the data in 1970, 1980, and 1990, and the same is true for the other variables included in the analysis.

Moreover, virtually every environmental inequality study I am aware of arbitrarily restricts itself in some way to a study area that limits variation in the data. For example, most quantitative environmental inequality studies focus on urban areas rather than rural areas, several urban environmental inequality studies exclude suburban areas from consideration, and only a few environmental inequality researchers have ever conducted statewide or national environmental inequality studies that would maximize data variation (see Szasz and Meuser 1997 for a review of the literature).

Nevertheless, a few words about the possible impacts of using my study area definition are in order. From 1970 to 1990, the metropolitan area suburbs outside my study area were virtually all white and by 1990 the city of Detroit was virtually all black. At the same time, the number of factories in Detroit, the county housing Detroit (Wayne county), and the study area cities just to the north of Detroit were declining, while the number of *metropolitan area* factories outside my study area were increasing. (Despite factory loss in the suburban cities included in my study area, the number of factories in the region's five suburban counties increased from 3,257 to 5,217 between 1970 and 1990.) Thus, the representation of blacks in facility neighborhoods was probably lower in the six-county metropolitan area than it was in my study area, and the proportion of factories sited in white neighborhoods between 1970 and 1990 was probably greater in the census-defined metropolitan area than it was in my study area. As a result, the regression models reported below are more likely to provide support for the simple segregation, racist intent, and economic models than they would if I used the Census Bureau's six-county definition.

Unit of Analysis

In this study, the unit of analysis is the census tract, except where census tracts were merged to examine change over time. Tract merging was necessary because census tract boundaries change from one decade to the next. I overcame this problem by creating dual-decade data sets for 1970/1980 and 1980/1990, preserving tract boundaries and data where possible and merging tract boundaries and data when necessary.

Merging was accomplished as follows. Count variables such as *total population* and *total number of families* were summed across merged observations, while population-weighted means were calculated for variables representing average values. For example, if tracts A, B, and C contain 80, 100, and 120 families respectively, and average family income in these tracts equals $20,000, $30,000, and $40,000 respectively, the number of families in the merged super-tract would equal 80 + 100 + 120, or 300, and the population-weighted mean family income in the merged super-tract would equal [($20,000*80) + ($30,000*100) + ($40,000*120)]/300. Variables representing average rather than median values were used in the merged data sets because the population-weighted mean of merged median values is not an accurate indicator of the true median value of the merged population.

Measuring Facility Presence

Since environmental inequality researchers do not know the actual health risk associated with specific environmental hazards or the residential location and demographic characteristics of every individual in their study area, they typically (a) aggregate the number of hazards or quantity of releases that exist in some specified census unit to create variables such as the pounds of TRI emissions in a census tract or the number of hazardous waste sites in a zip code (Bowen et al. 1995) or (b) use a dummy variable to record the presence or absence of some type of environmental hazard in specific analysis units

(Anderton et al. 1994a, b). These variables are then correlated with demographic variables to see whether environmental hazard levels vary with characteristics such as percent black and median household income.

Considerable information is lost, however, when environmental hazard indicators are constructed in these ways. This is because the actual location of each hazard is ignored when we create dummy variable hazard indicators or sum together the number of facilities or pounds of releases in each analysis unit. As a result, although many manufacturing facilities are located on or near tract boundaries, we are forced to assume either that these facilities do not impact people residing in adjacent tracts or that they impact every square inch of their home tract and adjacent tracts equally. We are also forced to assume that manufacturing facilities are evenly distributed within tracts, even though we know that they tend to cluster along major transportation routes (Northam 1979).

Finally, simple summing fails to take tract size into account. However, as you proceed further and further from Detroit's central business district, tract size increases. Percent black and median household income are also correlated with distance from the central business district. Thus, it turns out that percent black and median household income are correlated with tract area, a potentially important determinant of the number of facilities in a tract.

In order to overcome these problems, I created a new set of variables, not used in prior environmental inequality research, that take tract size, facility location, and the boundary problem into consideration. In order to create these new variables, I used geographic information system (GIS) mapping software to convert Detroit metropolitan area census tract maps into raster maps. Raster maps are rectangular grids typically composed of square cells. I created the new variables using 25-meter resolution grid cells, cells whose outer dimensions are 25 by 25 meters in length.

After converting the census tract maps to grids, I computed the number of facilities within a ¼ kilometer radius of the center of each grid cell and the distance, in meters, from the center of each grid cell to its nearest facility. Finally, for each of these variables, I took the sum of the values of all the cells in each tract and divided this sum by the number of cells in each tract. This gave me two new *tract-level* variables: the *average exposure* in a tract, or the number of facilities within a ¼ kilometer radius of the average tract cell, and the *average minimum distance* in a tract, or the distance from the average tract cell to its nearest facility.

These new indicators take facility location and tract size into account. They do not force us to assume that facilities are evenly distributed within tracts, that facilities have no affect on people residing in adjacent tracts, or that facilities impact every square inch of their host tract and adjacent tracts equally. Thus, these new indicators are clearly superior to the facility presence indicators typically used by environmental inequality researchers (see Downey 2003 for a more detailed discussion of this variable construction technique).

Analytic Strategy

As noted earlier, although the four models of environmental inequality make predictions about individual and firm-level behavior, data are available to test only the neighborhood-level predictions of these models, which I do using ordinary least squares (OLS) regression and visual map analysis (the visual inspection of maps). I use maps to examine the changing distribution of black neighborhoods and factory neighborhoods in the Detroit metropolitan area from 1970 to 1990 and OLS regression to test causal predictions derived from the explanatory models discussed above.

Because the explanatory models make predictions about the determinants of facility siting, racial succession, and income succession, the dependent variables in the regression models that follow are changes from one decade to the next (1970–1980 and 1980–1990) in percent black, average family income, and facility presence.

I use changes in facility presence rather than actual siting decisions to test economic and racist intent model predictions about facility siting decisions because I do not have siting decision data and cannot accurately measure siting decisions from the data I do possess. Nevertheless, because these explanatory models predict that the number of facilities sited in a tract should be negatively associated with tract incomes and positively associated with percent black, then *ceteris paribus* these models also predict that changes in facility presence from one decade to the next should be negatively associated with tract incomes and positively associated with percent black.

The regression equations take the following form:

$$\Delta\,\%\text{Black}_{(t,t-1)}=\text{B}_0+\text{B}_1\%\text{Black}_{t-1}+\text{B}_i\text{M}_{t-1}+\text{B}_j\text{C}_{t-1}, \quad (1)$$

$$\Delta\,\text{Average Income}_{(t,t-1)}=\text{B}_0+\text{B}_1\text{Average Income}_{t-1}+\text{B}_i\text{M}_{t-1}+\text{B}_j\text{C}_{t-1}, \quad (2)$$

$$\Delta\,\text{Facility Presence}_{(t,t-1)}=\text{B}_0+\text{B}_1\text{Facility Presence}_{t-1}+\text{B}_i\text{M}_{t-1}+\text{B}_j\text{C}_{t-1}, \quad (3)$$

where M_{t-1} represents a vector of independent variables used to test the represents a vector of control four models of environmental inequality and C_{t-1} variables drawn from the literatures on environmental inequality, neighborhood succession, and urban sociology.

Table 2 recategorizes the causal predictions listed in Table 1 according to the dependent variables used in the regression models, thereby providing a link between the explanatory models discussed above and the regression models presented below. It lists the independent variable concepts from Table 1 and their corresponding test variable indicators and tells us which explanatory models are tested by each indicator as well as the expected relationship between each test variable and its associated dependent variable.

For example, the top third of Table 2 lists the predictions that are tested when *facility presence change* is the dependent variable. Columns 1, 3, and 4 tell us that this dependent variable is used to test the prediction of the racist intent and economic models that the percentage of blacks in a neighborhood is positively associated with changes over time in facility presence and the prediction of the economic model that neighborhood incomes and property values are negatively associated with changes over time in facility presence. Column 2 tells us that the first prediction is tested using two test variable indicators, *percent black* and *percent black difference* (the change in percent black from time one to time two), and that the second prediction is tested using *average family income logged* and *average property value*.

Thus, the racist intent model is supported if *percent black* and *percent black difference* are positively associated with the dependent variable, and the economic model is supported if *percent black* and *percent black difference* are positively associated with the dependent variable and *average family income logged* and *average property value* are negatively associated with the dependent variable.

The number to the left of each independent variable concept in Table 2 indicates the order in which the independent test variables are inserted into the regression equations. In the *facility presence change* regression models, *percent black* and *percent black difference* are the first test variables inserted into the equation, followed by *average family income logged* then *average property value*. The control variables are inserted last. The logic behind the ordering differs across regression equations and is, therefore, discussed separately for each regression equation in the results section. Test and control variable definitions, as well as the logic behind the inclusion of specific control variables, are also discussed separately for each regression equation in the results section.

Table 2 shows that I use a different set of test variables in each regression equation. I do this because the explanatory models, taken as a whole, do not make the same predictions about each dependent variable. For example, although the racial succession model predicts that changes in percent black from one decade to the next will be greatest in neighborhoods immediately adjacent to already established black neighborhoods, *none* of the explanatory models predict that changes in average family income or facility presence will be affected by adjacency to already established black neighborhoods. Thus, it makes little sense to use the same test variables in each equation.

Finally, these regression models are potentially problematic because they contain temporally lagged endogenous variables (the dependent variable at time *t*–1) which, in the presence of temporal autocorrelation, are correlated with the error term, resulting in inconsistent and generally inflated parameter estimates (Ranger-Moore et al. 1995). Spatial autocorrelation is also a potential problem in these regression models. In order to determine whether spatial and temporal autocorrelation affected regression results, I ran models controlling for both. Since substantive results are nearly identical regardless of whether or not I control for these potential sources of bias, I present nonadjusted OLS results, with which readers are more familiar, in this article. (I note in the text the one case where results differed after controlling for spatial and temporal autocorrelation.)

Results

Table 3a correlates percent black and median family income with average minimum distance and average exposure in 1970, 1980, and 1990. I use median family income rather than average family income in Table 3a because single-decade census tract data does not need to be merged and median income data is generally considered to be preferable to average income data. Nevertheless, correlation results are nearly identical regardless of whether I use median or average income data.

Table 3a shows that in 1970, 1980, and 1990, average minimum distance and average exposure were both correlated with median family income and percent black in the expected direction. As median family income increased, average exposure decreased and average minimum distance—the distance from the average tract cell to its nearest facility—increased. As percent black increased, average exposure increased and average minimum distance decreased.

Table 3a also shows that the correlations between median family income, percent black, and the two facility presence indicators were considerably stronger in 1970 than in 1990. For example, the significant correlations between average minimum distance and percent black, which equaled −.15 in 1990, equaled −.29 in 1970, and the significant correlations between average exposure and percent black, which equaled .07 in 1990, equaled .17 in 1970.[4]

These results demonstrate that race- and income-based environmental inequality both existed in the Detroit metropolitan area throughout the period under study. But they also demonstrate that by 1990, race-based environmental inequality in the Detroit metropolitan area was relatively weak (as indicated by the weak correlations between percent black on the one hand and average exposure and average minimum distance on the other), and that this was so despite the fact that in 1990 income-based environmental inequality was still relatively strong and black families were still considerably poorer than white families (see Table 3b).

The maps and regression analyses that follow help us determine why black environmental inequality was so weak in 1990.

THE CHANGING DISTRIBUTION OF BLACK NEIGHBORHOODS AND FACTORY NEIGHBORHOODS, 1970–1990

Figure 1 examines tract-level changes in facility presence and the location of black neighborhoods from 1970 to 1980. It tests the prediction of the economic and racist intent models that changes in facility presence should be greater in black neighborhoods than white neighborhoods, the prediction of the economic and simple segregation models that blacks should be drawn disproportionately into facility presence tracts, and the prediction of the racial succession model that black neighborhoods and ghettos expand at their edges rather than into or along manufacturing neighborhoods and corridors.

In order to test the first prediction, the census tracts in maps (a) and (b) of Figure 1 are categorized according to changes in the total number of facilities in each tract from 1970 to 1980. The lightest-colored tracts in maps (a) and (b) represent tracts that lost between 1 and 15 facilities during the 1970s. However, only 3 of these 119 tracts lost more than 10 facilities, and only 9 lost more than 4 facilities. The tract that lost 15 facilities was in an all-white neighborhood, and the 2 tracts that lost between 10 and 15 facilities were in predominantly black neighborhoods. Finally, each dot in map (b) represents the residential location of 2000 blacks in 1970.[5]

Maps (a) and (b) contradict the prediction that changes in facility presence will be greater in black neighborhoods than in white neighborhoods. Although several black neighborhoods gained manufacturing facilities in the 1970s, it is apparent that in most black tracts, the number of facilities declined or remained constant. It is also apparent that facility increases occurred primarily outside Detroit's black ghetto. (The neighborhoods outside Detroit's black ghetto were overwhelmingly white in 1970 and 1980.)

Maps (c) and (d) test the prediction of the economic and simple segregation models that blacks will be drawn disproportionately into facility presence tracts and the prediction of the racial succession model that black neighborhoods and ghettos will expand at their edges rather than into or along manufacturing neighborhoods and corridors. In order to test these predictions, the census tracts in maps (c) and (d) are categorized according to average exposure.[6] (In the following section, I explain why average exposure is used to test some explanatory model predictions but not others.) Each dot in map (c) indicates the residential

[4]The 1970 and 1990 correlation coefficients for average minimum distance and percent black are significantly different at the 95% confidence level, the 1970 and 1990 correlation coefficients for average exposure and percent black are significantly different at the 93% confidence level, the 1970 and 1990 correlation coefficients for average minimum distance and median family income are significantly different at the 95% confidence level, and the 1970 and 1990 correlation coefficients for average exposure and median family income are significantly different at the 94% confidence level.

[5]Although it would have been preferable to assign a single dot for every 500 or 1,000 blacks residing in a tract, doing so made it difficult to see the tracts underneath. Moreover, because most tracts in the Detroit metropolitan area were virtually either all white or all black in 1970 and 1980, assigning each dot a lower value did not change the spatial relationships evident in Figures 1 or 2 in any substantively significant way.

[6]In Figure 1 and Figure 2, the spatial patterns observed in maps (c) and (d) are very similar regardless of whether I categorize census tracts according to *average exposure* or *the total number of facilities in a tract*.

location of 2,000 blacks in 1970, and each dot in map (d) indicates a 2,000-person increase from 1970 to 1980 in the number of blacks residing in a tract. (While it would be ideal to present an “average exposure” map without any dots, space considerations prevent me from doing so.)

Maps (c) and (d) contradict the prediction that blacks will be drawn disproportionately into facility presence tracts. While blacks clearly lived in many high-exposure tracts in 1970, blacks do not appear to have been drawn disproportionately into the metropolitan area’s other high-exposure tracts during the 1970s. In fact, virtually no blacks moved into the band of medium- to high-exposure tracts located just to the north of the metropolitan area’s 1970 black ghetto or into the pocket of low- to medium-exposure tracts to the southwest of the region’s 1970 black ghetto. Instead, Detroit’s black ghetto appears to have expanded at its northern, northeastern, and northwestern edges, as predicted by the racial succession model.

The same basic patterns hold in Figure 2, though changes in the total number of facilities in a tract appear to be more evenly distributed across black and white tracts in the 1980s than the 1970s. Thus, Figures 1 and 2 both contradict the prediction of the economic and racist intent models that changes in facility presence will be greater in black neighborhoods than in white neighborhoods and the prediction of the economic and simple segregation models that blacks will be drawn disproportionately into facility presence tracts. Conversely, Figures 1 and 2 both support the prediction of the racial succession model that black neighborhoods and ghettos expand at their edges rather than into or along manufacturing neighborhoods and corridors. (Maps not shown here demonstrate that the same basic spatial patterns held from 1920 to 1970.) Thus, the racial succession model is the only explanatory model supported by the evidence presented in this section.

In order to confirm this conclusion quantitatively and test additional explanatory model predictions, I now turn to regression analysis.

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FACILITY PRESENCE

The dependent variable in the first set of regression analyses is *the change from one decade to the next in the total number of facilities in a tract* (the total number of facilities in a tract at time two minus the total number of facilities in a tract at time one). I use this facility presence indicator rather than changes in average exposure or average minimum distance because average exposure and average minimum distance are affected by the presence and distribution of facilities in adjacent tracts. Thus, in any given tract, the values of these variables and changes in their values from one decade to the next are determined by the values of test and control variables in multiple tracts. Moreover, *total facility change* is a better proxy for siting decisions than are changes in average exposure or average minimum distance. Nevertheless, I obtain essentially the same results no matter which facility presence indicator I use, and this is true for all the regression models included in this article.

The results are listed in Table 4 (see Table 2 for predicted relationships). The first two test variables, *percent black* and *percent black difference* (the change in percent black from one decade to the next), test the racist intent model, which holds that facilities are more likely to be sited in black neighborhoods than in white neighborhoods because decision makers and their constituents are racially prejudiced. Thus, percent black and percent black difference should be positively associated with the dependent variable.

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Average family income logged tests the prediction of the economic model that facilities will be sited in neighborhoods with low incomes. Thus, this variable should be negatively associated with the dependent variable. Moreover, because the economic model holds that racially inequitable siting decisions are the result of black-white income inequality rather than overt racial bias, the inclusion of this variable in the model should wash out or weaken any positive association that exists between the dependent variable and the first two test variables.

Finally, *average property value* tests the prediction of the economic model that facilities will be sited in low-income neighborhoods because property values are low in these neighborhoods and firms site facilities where property values are low. Thus, *average property value* should be negatively associated with the dependent variable, and its inclusion in the regression equation should wash out or weaken any negative association that exists between average family income logged and the dependent variable.

The control variables are listed below the test variables. The first control variable is the dependent variable at time one. *Detroit* is a dummy variable set equal to one if a tract is located in the city of Detroit and zero otherwise. It is included because central-city location has become an important negative determinant of manufacturing facility siting decisions in recent decades (Darden et al. 1987; Farley, Danziger, and Holzer 2000; Sugrue 1996). *Facility density* (the number of manufacturing facilities per km^2) and population density (the number of people per km^2) are included because manufacturing facilities are often sited near other manufacturing facilities but in areas with plenty of open space (Northam 1979; Sinclair 1972).[7] The *percentage of housing units that are owner occupied* and the *percentage of people five years old and older living in the same house as five years ago* are included because it is hypothesized that residential stability is negatively associated with facility presence change.[2] The *percentage of workers employed in manufacturing* is included because it is hypothesized that firms attempt to site factories near potential employees (Anderton et al. 1994a, b), and *railroad distance logged* is included because Detroit metropolitan area manufacturing facilities tend to be located near the region's railroad lines (Sinclair 1972).[9] Finally, all the independent variables except percent black difference are measured solely at time one.

The results listed in Table 4 contradict both the racist intent model and the economic model: regardless of whether the control variables are included in the regression model, percent black and percent black difference are never positively associated with the dependent variable and average family income logged, and average property value are never negatively associated with the dependent variable.

One possible explanation for these results is that low-income tracts, low property value tracts, and tracts with high percentages of blacks were already saturated with manufacturing facilities in 1970 and 1980, making it impossible for new facilities to be sited in them. However, this was not the case. Data not reported here show that in the Detroit metropolitan area in 1970, 1980, and 1990, there were many low- and medium-income tracts, low and medium property value tracts, and tracts with high percentages of blacks with relatively few or no manufacturing facilities.

ECONOMIC SUCCESSION

The dependent variable in the second set of regression analyses is *the change in average family income from one decade to the next* (average family income at time two minus

[7]The facility density indicator really measures the density of facilities included in my data set. While it would have been preferable to have density data for all manufacturing facilities, such data were not available. Nevertheless, this indicator is better than no indicator and it is negatively associated with the 1970/1980 dependent variable.

[9]*Percent employed in manufacturing* is defined as the percentage of individuals in a tract who are 16 years old or older and are employed in one of the following occupational categories: precision production, craft, and repair; machine operators, assemblers, and inspectors; and handlers, equipment cleaners, helpers, and laborers. *Railroad distance logged* is the natural log of the distance in meters from the center of each tract (or merged "super-tract") to the nearest railroad.

average family income at time one, with 1970 and 1980 average family income converted to 1990 dollars). All the independent variables except for *average exposure change*, *average property value change*, and *average gross rent change* are measured solely at time one.

The results are listed in Table 5 (see Table 2 for the predicted relationships). All six test variables test the economic model, which predicts that neighborhood incomes will decline over time, relative to overall area incomes, in facility neighborhoods and in neighborhoods with low property values and low rents. Specifically, the model holds that average exposure and changes in average exposure from one decade to the next (*average exposure change*) should be negatively associated with neighborhood income change because facility presence lowers neighborhood property values and rents, leading wealthier individuals to flee facility neighborhoods and poorer ones to move in. Thus, the dependent variable should be negatively associated with the two facility presence indicators and positively associated with average property value, average property value change, average gross rent, and average gross rent change. Moreover, including the property value and rent variables in the equation should wash out or weaken any negative association that exists between the facility presence variables and neighborhood income change.

The control variables are listed below the test variables. The first control variable is the dependent variable at time one. *Detroit* is a dummy variable set equal to one if a tract is located in the city of Detroit and zero otherwise. It is included because inner-city incomes have declined dramatically relative to suburban incomes in many major metropolitan areas since 1970 (Massey and Denton 1993; Sugrue 1996; Wilson 1987). All the remaining control variables except the percentage of workers employed in manufacturing and railroad distance logged are drawn from the literature on economic succession. Economic succession can be defined as the “replacement of nonpoor residents by poor residents within the boundaries of a given neighborhood” (modification of White 1984:165) and is generally viewed as a function of household mobility, neighborhood racial composition, the age and condition of the housing stock, and the proximity of nonpoor neighborhoods to poor neighborhoods, which can be operationalized as the average family income in the poorest adjacent tract (Phillips 1981; Vandell 1981).

The percentage of workers employed in manufacturing is included because it is hypothesized that economic succession occurred disproportionately in working-class neighborhoods due in large part to the declining fortunes of manufacturing workers in the 1970s and 1980s (Wilson 1987). Finally, railroad distance logged is included because it is hypothesized that economic succession occurred first near Detroit’s railroad lines, where incomes tend to be relatively low and services poorly developed (Sinclair 1972), and over time progressively further from these lines.

The results listed in Table 5 show that neither average exposure nor average exposure change is significantly associated with the dependent variable in any of the regression models. However, average property value and average property value change are both positively associated with the dependent variable in both decades (models 2, 3, 5, and 6).

Thus, the economic model is only partially supported. Its prediction that average property value and average property value change are positively associated with income change is supported, but its predictions that facility presence and facility presence change are negatively associated with income change and that average gross rent and average gross rent change are positively associated with income change are not supported. Moreover, results not reported here show that neither average exposure nor average exposure change is a significant predictor of average property value change or average rent change when these latter two variables are inserted into the regression equation as dependent variables. Thus, the economic model prediction that facility presence has a negative impact on property values and rents is also contradicted.

One might argue that facility presence is not negatively associated with average income change, average property value change, or average gross rent change because facility presence tracts had already experienced severe declines in incomes, property values, and rents prior to 1970. Perhaps incomes, property values, and rents in these tracts had declined as much as they could decline by 1970.

Analyses not reported here demonstrate that this was not the case. These analyses compare the incomes, property values, and rents in the Detroit metropolitan area's highest facility presence tracts to the incomes, property values, and rents in the region's other tracts and find that in 1970, 1980, *and* 1990, incomes, property values, and rents were relatively high in many of the region's highest facility presence tracts. The same pattern of results is also found when we compare the highest facility presence tracts in the city of Detroit with other "city of Detroit" tracts. Thus, we can safely conclude that the economic model is only partially supported by the results presented in Table 5.

RACIAL SUCCESSION

The dependent variable in the last set of regression analyses is *the change in percent black from one decade to the next* (percent black at time two minus percent black at time one). All the independent variables except *average exposure change*, *average property value change*, and *average gross rent change* are measured solely at time one. The results are listed in Table 6. The first two test variables, *average exposure* and *average exposure change*, test the economic and simple segregation models, which predict that blacks will be drawn disproportionately into facility presence tracts. They also test the racial succession model, which predicts that blacks will *not* be drawn disproportionately into facility presence tracts. Thus, the economic and simple segregation models are supported if *average exposure* and *average exposure change* are positively associated with the dependent variable, and the racial succession model is supported if these two test variables are *not* positively associated with the dependent variable.[10]

The economic model, which predicts that blacks are drawn to facility neighborhoods because facility neighborhoods have low property values and low rents, is also tested by the following four variables: *average property value*, *average property value change*, *average gross rent*, and *average gross rent change*. If the economic model is correct, these four variables should be negatively associated with the dependent variable and their inclusion in the regression equation should wash out or weaken any positive association that exists between the facility presence variables and the dependent variable.

The last three test variables, *black ghetto*, *black ring 2*, and *black ring 3*, are a set of dummy variables created by designating census tracts as belonging to a black ghetto, a ring of tracts immediately adjacent to the black ghetto (ring 1), a ring of tracts immediately adjacent to ring 1 (ring 2), and the remainder of the tracts in the region (ring 3). These variables test the prediction of the racial succession model that racial succession occurs primarily at the edges

[10]Of course, percent black can increase if the number of blacks in a tract increases *or* the number of nonblack tract residents decreases. Thus, if any of the test variables are positively associated with *percent black change* it could be due to black in-migration, white out-migration, or both. Increases in *percent black* due to white out-migration are not inconsistent with economic or simple segregation model predictions, however, because both models expect that whites will be drawn away from facility presence tracts in disproportionate numbers. The economic model expects this to happen because whites are, on average, wealthier than blacks, and the model holds that wealthier individuals will flee facility neighborhoods, and the simple segregation model expects this to occur because whites have greater residential choice than blacks. Finally, the racial succession model holds that racial succession is due to black in-migration *and* white out-migration.

of the black ghetto. Thus, the model is supported if the change in percent black from one decade to the next is lower in rings 2 and 3 than it is in ring 1. In other words, the model is supported if rings 2 and 3 are both negatively associated with the dependent variable.

A census tract is defined as belonging to a black ghetto if at least 15% of its residents are black. This threshold was chosen based on Emerson, Chai, and Yancey's (2001) finding that whites are unlikely to buy a house in a neighborhood that is more than 15% black, suggesting that whites consider such neighborhoods to be undesirable because they view them as either being black neighborhoods or being on the road to becoming black neighborhoods. Because some readers might find this threshold too low, I ran a set of models using a 30% black ghetto threshold. These models are not reported because their results are substantively identical to the results reported here.

The control variables are listed below the test variables. The first control variable is the dependent variable at time one. *Detroit* is a dummy variable set equal to one if a tract is located in the city of Detroit and zero otherwise. It is included because the boundary between Detroit and its suburbs has played an important role in shaping residential segregation in the region (Darden et al. 1987; Sugrue 1996). All the remaining control variables except the percentage of workers employed in manufacturing and railroad distance logged are drawn from the literature on racial succession. Racial succession is generally viewed as a function of white geographic mobility (Steinnes 1977), the age and condition of the housing stock (Wilson 1983), and the proximity of white neighborhoods to nonwhite neighborhoods (Denton and Massey 1993; Steinnes 1977). The percentage of workers employed in manufacturing is included because it is hypothesized that racial succession is less likely in working-class neighborhoods (Sugrue 1996), and railroad distance logged is included because railroads have had a pronounced effect on residential development and succession in the Detroit metropolitan area (Sinclair 1972).

The results listed in Table 6 show that neither *average exposure* nor *average exposure change* is significantly associated with the dependent variable in either decade. Thus, the prediction of the simple segregation and economic models that blacks are drawn disproportionately into facility presence tracts is contradicted, while the prediction of the racial succession model that blacks are *not* drawn disproportionately into facility presence tracts is supported.

Of course, if high facility presence tracts were predominantly black in 1970 and 1980, then the percentage of people in these tracts who were black could not have increased very much from 1970 to 1980 or from 1980 to 1990, making it highly unlikely that facility presence would be positively associated with the dependent variable in either decade. However, data not reported here demonstrate that in 1970, 1980, and 1990 many high facility presence tracts in the Detroit metropolitan area had few or no blacks. Moreover, as late as 1980, many high facility presence tracts *within* the city of Detroit had few or no blacks. Thus, we can safely conclude that the prediction of the simple segregation and economic models that blacks are drawn disproportionately into facility presence tracts is contradicted, while the prediction of the racial succession model that blacks are *not* drawn disproportionately into facility presence tracts is supported.

The remaining models include all nine test variable predictors. I do not present the intermediate models that include the facility presence, property value, and rent variables, but not the black ghetto and ring variables, for two reasons. First, because the facility presence variables are not significantly associated with the dependent variable in models 1 and 4, it is not necessary to determine whether including the property value and rent variables in the regression equation weakens the association (that does not exist) between the facility presence variables and the dependent variable. Second, the substantive interpretations of the property value and rent coefficients are identical regardless of whether the black ghetto and ring variables are inserted into the equation.

Model 2 includes all the test variable predictors but only one control variable. In this model, the 1970/1980 dependent variable is negatively associated with average property value, average property value change, and black rings 2 and 3 and is positively associated with average gross rent, average gross rent change, and black ghetto. Results are only slightly different when the remaining control variables are inserted into the equation in model 3: with the remaining control variables included, average gross rent change and black ghetto are no longer statistically significant.

In models 5 and 6, on the other hand, the only significant test variable coefficients are the coefficients for the black ghetto and ring variables. Black ghetto is positively associated with the 1980/1990 dependent variable in both models, and black rings 2 and 3 are negatively associated with the 1980/1990 dependent variable in both models.[11]

Thus, the racial succession model is fully supported by the results presented in Table 6: in neither decade were changes in percent black affected by facility presence levels and in both decades changes in percent black were higher in ring 1 tracts than in ring 2 or ring 3 tracts.

The economic model, on the other hand, is only weakly supported by the results presented in Table 6. Its prediction that average property value and average property value change are negatively associated with the dependent variable is supported in the 1970s but not the 1980s. Its prediction that average gross rent and average gross rent change are negatively associated with the dependent variable is contradicted in both decades. Moreover, as noted above, blacks were not drawn disproportionately into facility presence tracts as both the economic and simple segregation models predict should occur.

Discussion

The racial succession model is the only model of environmental inequality fully supported by the regression and map analyses reported above. Moreover, it is the only explanatory model tested in this article that receives more than weak support from these analyses. Consistent with its expectation that black ghettos expand at their edges rather than along urban manufacturing corridors, changes in percent black from one decade to the next were higher in tracts immediately adjacent to Detroit’s black ghetto than they were in other nonghetto tracts. But contrary to the expectations of the economic and simple segregation models, blacks were not drawn disproportionately into manufacturing facility neighborhoods, and contrary to the expectations of the economic and racist intent models, changes in facility presence from one decade to the next were not associated in the expected direction with neighborhood racial status, neighborhood income levels, or neighborhood property values. Moreover, evidence not reported here shows that from 1920 to 1970 Detroit’s black ghetto also expanded at its edges rather than along the city’s manufacturing corridors.

Thus, the 1990 distribution of blacks and whites around Detroit metropolitan area manufacturing facilities was not the result of racist siting practices or black/ white income inequality.[12] This distribution was shaped, however, by residential segregation, which limited blacks’ residential options to housing in or at the edges of already established black

[11]I noted earlier that regression results are nearly identical regardless of whether or not I control for spatial and temporal autocorrelations. The one exception occurs in Table 6. When I control for spatial and temporal autocorrelation in Table 6, average property value is no longer significantly associated with the 1970/1980 dependent variable.

neighborhoods, thereby preventing them from being drawn disproportionately into manufacturing neighborhoods and corridors that lay far beyond the boundaries of Detroit's black ghetto.

As others have documented (Darden et al. 1987; Farley, Danziger, and Holzer 2000), residential segregation also directed blacks away from Detroit's most heavily industrialized suburb, Warren, and toward two relatively nonindustrial suburbs, Oak Park and Southfield, despite the fact that housing was significantly less expensive in Warren than in Oak Park and Southfield and that 30% of Warren's workforce was black in 1970. According to Darden et al. (1987), blacks migrated to Southfield and Oak Park rather than to Warren because white resistance to black settlement was much stronger in working-class Warren than in middle-class Southfield and Oak Park. White resistance was exceptionally strong in Warren, they argue, because Warren's white working-class population had fled Detroit in order to avoid living with blacks and was determined to neither flee nor live near blacks again.

Figure 3, which maps out the 1990 distribution of blacks and manufacturing facilities in the Detroit metropolitan area, illustrates the degree to which residential segregation *within suburbia* separated the region's blacks from suburban manufacturing activity. While almost all of Southfield's census tracts were at least 10% black and more than half of Southfield's and Oak Park's census tracts were at least 20% black, only seven of the region's other suburban census tracts were more than 5% black. (The map in Figure 3 does not show the 5% cutoff point.) As a result, although blacks surrounded almost all the manufacturing facilities located in Detroit in 1990, virtually no blacks lived in the heavily industrialized manufacturing corridors located just to the north of the eastern two-thirds of Detroit.

It should be clear, then, that in the Detroit metropolitan area, residential segregation has played a dual role in shaping environmental racial inequality. It has prevented Detroit's black ghetto from expanding along the region's manufacturing corridors and allowed blacks to move into some suburbs but not others—and as many researchers have shown, residential segregation is a product of white racism, not black income levels or black housing preferences (Galster et al. 1987; Massey and Denton 1993; Yinger 1991a, b). Thus, racial status and racism *are* important determinants of environmental racial inequality in the Detroit metropolitan area, but in this case they operated indirectly through the housing market and acted to separate blacks from manufacturing facility pollution.

Conclusion

This conclusion is, of course, consistent with Massey and Denton's argument that racial status continues to play a decisive role in shaping racial inequality and that housing market racism has a significant impact on racial inequality in other institutional arenas. It is also consistent with spatial mismatch theory, which predicts that residential segregation and industrial flight have created a spatial mismatch between black neighborhoods and manufacturing facility employment.

[12]If racist siting practices had played a role in shaping environmental inequality in the Detroit metropolitan area, changes in facility presence from one decade to the next would have been positively associated with percent black in Table 4. If black/white income inequality had played a role in shaping environmental racial inequality in the region, percent black would have been positively associated with facility presence change in Table 4, average family income logged would have been negatively associated with facility presence change in Table 4, and the negative association that was expected between facility presence change and average family income logged in Table 4 would have washed out or weakened the positive association that was expected between percent black and facility presence change. Moreover, facility presence would have been negatively associated with average family income change in models 1 and 4 in Table 5.

Nevertheless, this conclusion also highlights an important shortcoming common to both segregation theory and spatial mismatch theory: the need to recognize that residential segregation sometimes separates minorities from socially undesirable goods. Determining the conditions under which segregation is likely to do this is clearly beyond the scope of this article. However, I would hypothesize that such conditions are relatively rare, existing primarily in situations where socially desirable and undesirable goods are tied to one another spatially (as is the case with manufacturing jobs and manufacturing pollution) such that residential segregation allows whites to monopolize a socially desirable good while simultaneously forcing them to live near a spatially linked undesirable good. Thus, segregation is likely to have this surprising and unintended effect in only a limited number of situations.

In addition to contributing to our understanding of residential segregation, this article demonstrates that environmental inequality researchers need to pay more attention to the broader sociological literature on race, urban development, and urban neighborhood ethnic dynamics from which the racial succession model was drawn. Doing so will not only help us develop more nuanced explanations of urban environmental inequality, it will also allow environmental inequality researchers to engage in important sociological debates concerning urban housing and labor markets, racial and ethnic competition, residential segregation, neighborhood succession, spatial mismatch, and group conflict over urban space.

Finally, it should be noted that although this study examines only one type of environmental hazard, the spatial distribution of this hazard is quite similar to that of other Detroit metropolitan area environmental hazards: the region’s superfund sites, large-quantity hazardous waste generators, and hazardous waste treatment, storage, and disposal facilities (TSDFs) are all located in the same set of industrial corridors as are polluting manufacturing facilities, though TSDFs are more highly concentrated in the city of Detroit than are the other hazards (maps available upon request).

This suggests that in the Detroit metropolitan area, the factors and processes determining who lives near superfund sites and hazardous waste sites are probably quite similar to the factors and processes determining who lives near polluting manufacturing facilities. In addition, it suggests that although the location of urban environmental hazards is probably heavily constrained by the location of urban industrial corridors, the factors affecting the distribution of hazards within these corridors probably vary across hazards. Determining what these factors are and whether they are related to market dynamics, the infrastructural or geophysical needs of different kinds of facilities, the social desirability of different types of hazards (i.e., factories vs. hazardous waste dumps), the ability of different neighborhoods to attract or repel differently valued hazards, or some other set of determinants would contribute greatly to our understanding of urban environmental inequality, as would replicating this study in other metropolitan areas to see if the patterns uncovered in Detroit hold in other regions of the country.

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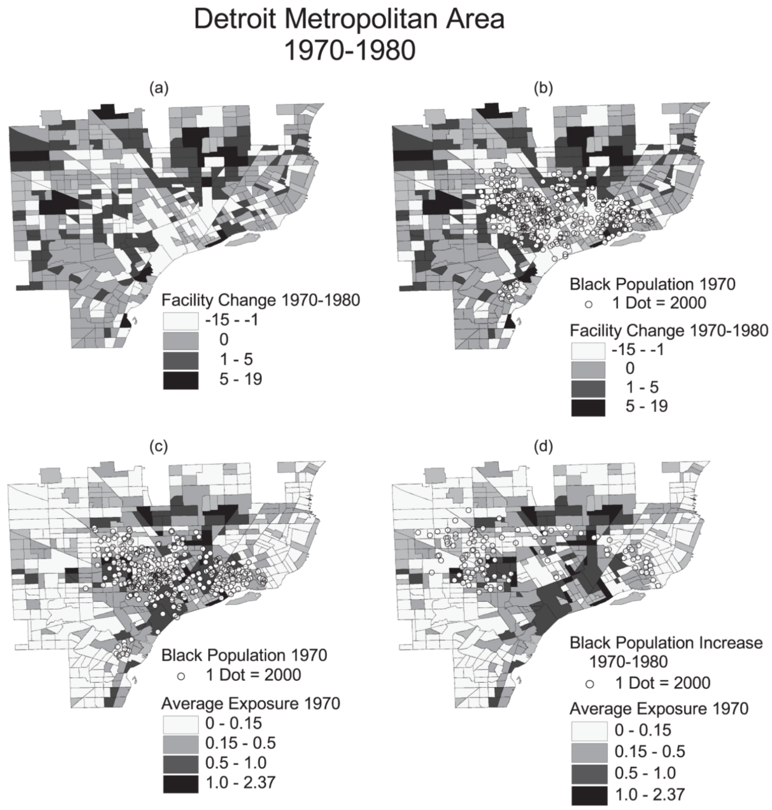

Figure 1.
Tract-Level Changes in Facility Presence and the Location of Black Neighborhoods, 1970–1980

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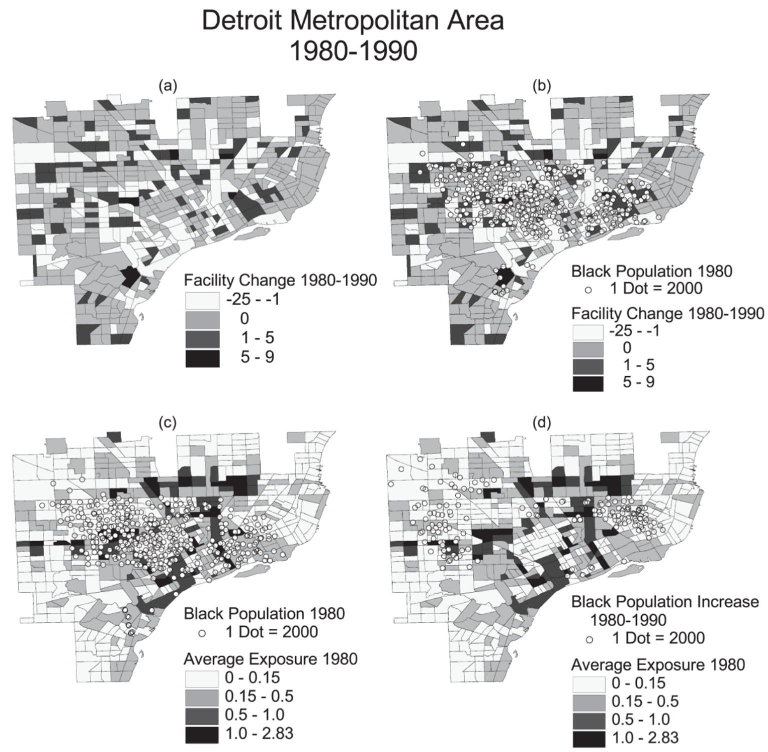

Figure 2.

Tract-Level Changes in Facility Presence and the Location of Black Neighborhoods, 1980–1990

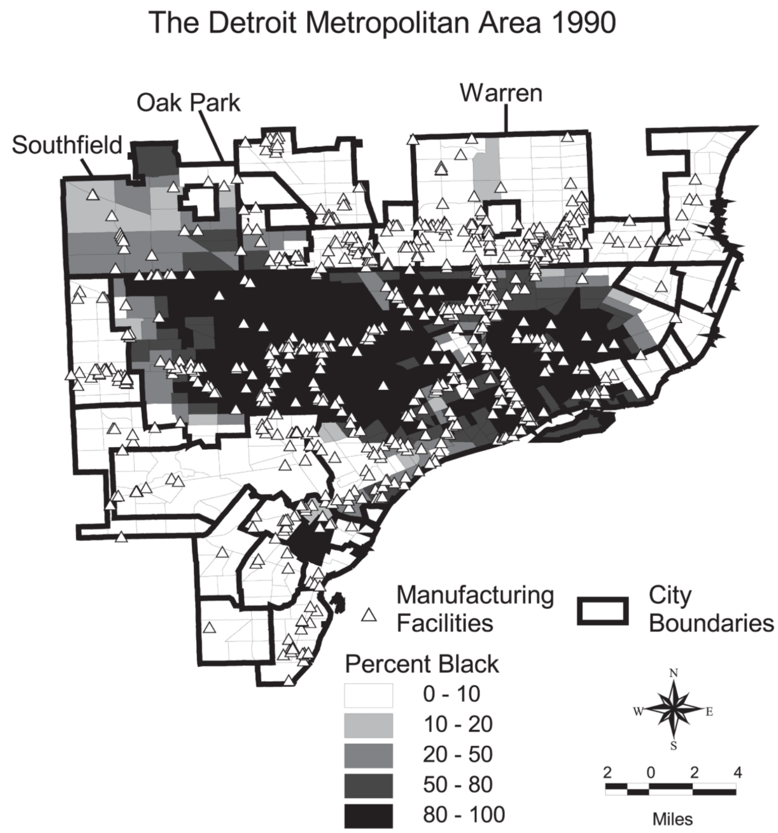

Figure 3.
Black Settlement Patterns and Regional Manufacturing: Detroit Metropolitan Area, 1990

Table 1

Explanatory Model Predictions

Economic Model Predictions		
Dependent variable concepts	*Independent variable concepts*	*Expected relationship*
Facility presence and facility change	Neighborhood incomes	Negative
	Neighborhood property values	Negative
	Percent black	Positive
Income change	Facility presence	Negative
	Property values	Positive
	Rents	Positive
Percent black change	Facility presence	Positive
	Property values	Negative
	Rents	Negative
Racist Intent Model Predictions		
Dependent variable concepts	*Independent variable concepts*	*Expected relationship*
Facility presence and facility change	Percent minority	Positive
Simple Segregation Model Predictions		
Dependent variable concepts	*Independent variable concepts*	*Expected relationship*
Percent black change	Facility presence	Positive
Racial Succession Model Predictions		
Dependent variable concepts	*Independent variable concepts*	*Expected relationship*
Percent black change	Neighborhood adjacency	Positive
	Facility presence	Not positive

Table 2

Regression Model Predictions

Dependent Variable: Facility Presence Change			
Independent variable concepts	*Independent test variables*	*Explanatory model*	*Expected relationship*
1. Percent black	Percent black	Racist intent model	Positive
	Percent black difference	Economic model	Positive
2. Neighborhood incomes	Average family income logged	Economic model	Negative
3. Neighborhood property values	Average property value	Economic model	Negative
Dependent Variable: Income Change			
Independent variable concepts	*Independent test variables*	*Explanatory model*	*Expected relationship*
1. Facility presence	Average exposure	Economic	Negative
	Average exposure change		
2. Neighborhood property values	Average property value	Economic	Positive
	Average property value change		
2. Neighborhood rents	Average gross rent	Economic	Positive
	Average gross rent change		
Dependent Variable: Percent Black Change			
Independent variable concepts	*Independent test variables*	*Explanatory model*	*Expected relationship*
1. Facility presence	Average exposure	Economic	Positive
	Average exposure change	Simple segregation	Positive
		Racial succession	Not positive
2. Neighborhood property values	Average property value	Economic	Negative
	Average property value change		
2. Neighborhood rents	Average gross rent	Economic	Negative
	Average gross rent change		
2. Adjacency	Black ghetto	Racial succession	—
	Black ring 2		Negative
	Black ring 3		Negative

Table 3(a)

Kendall Tau-b Correlation Coefficients for Average Exposure, Average Minimum Distance, Percent Black, and Median Family Income, 1970–1990

	Median Family Income		
	1990	**1980**	**1970**
Average minimum distance	.279***	.351***	.396***
Average exposure	−.171***	−.239***	−.272***
	Percent Black		
	1990	1980	1970
Average minimum distance	−.152***	−.187***	−.295***
Average exposure	.074*	.079**	.175***

* $p < .05$

** $p < .01$

*** $p < .001$

Table 3(b)

Mean Family Income and Family Poverty Rates for Blacks and Whites in the Detroit Metropolitan Area, 1990[a]

	Black	White	Black/White Ratio
Mean family income	$26,059	$36,969	.70
Percentage of families in poverty	31	8	3.87

[a] I use mean rather than median family income because it is not possible to calculate a single median family income for Detroit and the cities immediately surrounding Detroit without access to individual census records.

Table 4

Regression of "Change in the Total Number of Facilities In a Tract From One Decade To the Next" on Test and Control Variables, 1970–1980 and 1980–1990

	Model 1 (1970–1980)	Model 2 (1970–1980)	Model 3 (1970–1980)	Model 4 (1970–1980)	Model 5 (1980–1990)	Model 6 (1980–1990)	Model 7 (1980–1990)	Model 8 (1980–1990)
Intercept	.455**	.342	−3.516	.528	.215	−3.860	−9.337*	−7.958
Test variables								
Percent black	−.008*	−.008	−.008	−.004	.000	.002	.002	.007
Percent black difference	−.004	−.004	−.005	−.003	−.003	−.003	−.004	.004
Average family income logged	—	.012	.472	.117	—	.398	.986*	.926
Average property value	—		.000	.000	—	—	.000	.000
Control variables								
Total number of facilities$_{(t-1)}$	−.584*	−.058*	−.059*	−.036	−.262***	−.255***	−.255***	−.306***
Detroit	—	—	—	.293	—	—	—	−.391
Facility density	—	—	—	−.222**	—	—	—	.060
Population density	—	—	—	−.000**a	—	—	—	−.000a
Percent same house as five years ago	—	—	—	−.016	—	—	—	−.001
Percent owner occupied	—	—	—	.008	—	—	—	−.000a
Percent employed in manufacturing	—	—	—	.036	—	—	—	.037
Railroad distance logged	—	—	—	−.086	—	—	—	−.151*
R^2	.030	.030	.035	.091	.309	.312	.315	.334
N	416	416	416	416	494	494	494	494

[a]Coefficient < 0

* $p < .05$

** $p < .01$

*** $p < .001$

Table 5

Regression of "Change in Average Family Income From One Decade To the Next" On Test and Control Variables, 1970–1980 and 1980–1990

	Model 1 (1970–1980)	Model 2 (1970–1980)	Model 3 (1970–1980)	Model 4 (1980–1990)	Model 5 (1980–1990)	Model 6 (1980–1990)
Intercept	−4491.084***	−2558.067*	5295.643	−9274.196***	233.217	−8192.556*
Test variables						
Average exposure	−1546.402	−610.837	−734.490	−403.921	−854.116	−238.682
Average exposure change	1317.222	1559.376	44.841	−358.054	−1680.732	−1095.155
Average property value	—	.034***	.063***	—	.254***	.274***
Average property value change	—	.122***	.108***	—	.245***	.234***
Average gross rent	—	5.693	−7.708	—	6.015	6.185
Average gross rent change	—	5.264	−4.501	—	5.664	7.256
Control variables						
Average family income$_{(t-1)}$	−.033	−.167***	−.381***	.222***	−.383***	−.433***
Detroit	—	—	−2830.737***	—	—	380.979
Percent black	—	—	7.914	—	—	7.047
Average family income in the poorest adjacent tract	—	—	.024	—	—	.007
Percent owner occupied	—	—	82.900***	—	—	27.817
Percent families with children	—	—	34.406	—	—	14.494
Percent housing more than 30 years old	—	—	−34.007**	—	—	40.906**
Percent same house as five years ago	—	—	37.071*	—	—	22.542
Percent high school graduates	—	—	58.109	—	—	45.788
Percent employed in manufacturing	—	—	−56.127	—	—	−69.303
Railroad distance logged	—	—	−501.303**	—	—	48.823
R^2	.017	.198	.483	.194	.517	.549
N	416	416	416	494	494	494

* $p < .05$

** $p < .01$

*** $p < .001$

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Table 6

Regression of "Change in Percent Black From One Decade To the Next" On Test and Control Variables, 1970–1980 and 1980–1990

	Model 1 (1970–1980)	Model 2 (1970–1980)	Model 3 (1970–1980)	Model 4 (1980–1990)	Model 5 (1980–1990)	Model 6 (1980–1990)
Intercept	14.376***	18.204***	123.733**	8.976***	4.697	31.259
Test variables						
Average exposure	4.819	−5.542	1.598	.069	−2.743	.947
Average exposure change	−5.419	−4.483	−.377	3.319	2.557	3.727
Average property value	—	−.000***a	−.000***a	—	.000	−.000a
Average property value change	—	−.000***a	−.000***a	—	−.000a	.000
Average gross rent	—	.058***	.029*	—	.017	−.001
Average gross rent change	—	.030*	.022	—	.021	.009
Black ghetto	—	13.108**	1.178	—	34.150***	25.352***
Black ring 2	—	−16.102***	−14.289***	—	−6.339***	−6.644***
Black ring 3	—	−29.797***	−28.799***	—	−14.497***	−10.639***
Control Variables						
Percent black$_{(t-1)}$	−.044	−.428***	−.336***	.014	−.449***	−.411***
Detroit	—	—	19.445***	—	—	11.016***
Percent owner occupied	—	—	.049	—	—	.096**
Percent families with children	—	—	−.132	—	—	−.071
Percent housing more than 30 years old	—	—	−.102*	—	—	−.056*
Percent same house as five years ago	—	—	−.364***	—	—	−.253***
Percent high school graduates	—	—	.794***	—	—	.199***
Average family income logged	—	—	−8.575	—	—	−1.650
Percent employed in manufacturing	—	—	−.637***	—	—	−.309*
Railroad distance logged	—	—	.320	—	—	.659*
R^2	.009	.364	.613	.002	.585	.698
N	416	416	416	494	494	494

[a]Coefficient < pa0

* $p < .05$

** $p < .01$

*** $p < .001$