Socio-Economic Composition and Uniform Partial Ranking of US County-Level Environmental Quality

Essie Maasoumi footnote
Southern Methodist University
Daniel L. Millimet
Southern Methodist University
September 2001

ABSTRACT.

The distribution of pollution is of just as much concern as the level of pollution, particularly if the areas located in the upper tail of the distribution are not randomly assigned. The literature on 'environmental discrimination' typically finds that even conditional on various locational attributes, areas concentrated with minorities experience higher *mean* pollution levels. However, claims of environmental discrimination based upon only the first moment of a conditional (or unconditional) distribution may be narrow and disregard the remainder of the distribution and more informative welfare evaluations. This shortcoming is addressed by adapting recent developments in the stochastic dominance literature to test for unambiguous rankings between various distributions of toxic releases. Using county-level data from the EPA from 1990 – 1999, we find ...

Key Words: Pollution, Stochastic Dominance, Nonparametric Tests, Environmental Discrimination

Introduction

The spatial distribution of pollution and other environmental hazards continues to be well studied and has important policy implications. Several studies have found evidence linking race and the distribution of environmental quality (Arora and Carson 1999; Brooks and Sethi 1997; Gelobter 1992; Gianessi et al. 1979; among others). Empirical evidence of such adverse environmental association or environmental "inequity", however, is typically based on standard regression techniques. In this approach, after controlling for other location-specific attributes likely to impact environmental quality, a greater concentration of nonwhite population is found *on average* to be associated with lower environmental quality. In other words, the *conditional mean* of environmental quality is reported to be lower in areas with a higher concentration of minorities. For example, Brooks and Sethi (1997) find *ceteris paribus* that a 1% increase in the proportion of African-Americans in a zip code corresponds to roughly a 3% increase in (distance-weighted) toxic releases.

While such regression based analyses yield easily interpretable results, and extremely useful in identifying important associations for policy makers, the approach is lacking in defining the "effect", and in the proper evaluation of "incidence" and well-being. By providing "complete" ranking of welfare states based on limited and implicit welfare criteria, the current techniques can produce a false sense of decisiveness. Put differently, it is not at all clear why the average level of pollutants (and/or its variance) is a suitable measure of wellbeing or welfare impact of pollution. Evaluations that are based on large classes of welfare functions offer partial but uniform comparisons, and an opportunity for "consensus" or broader-based evaluations of environmental states. This approach requires more sophisticated techniques and knowledge of the whole distribution of pollutants. Building on recent advances in the income inequality and finance literature, testing for *stochastic dominance* allows us to (potentially) rank the distribution of emissions in locations inhabited by whites versus locations inhabited by nonwhites at a given point in time. In addition, one can examine the evolution over time of the whole distribution of emissions *for a given location* inhabited by any group in the population, or characterized by any other policy relevant attribute. Such rankings, to the extent that they may be established empirically, are essential for policy evaluation and (owing to their robustness to wide classes of social welfare functions) rather commanding.

The power of such stochastic dominance relations, combined with the recently developed theory necessary to conduct statistical tests for the presence of such relations, has led to their growing application. For example, Maasoumi and Heshmati (2000, 2001) analyze changes, respectively, in the Swedish and PSID income distribution over time as well as across different population subgroups. Bishop et al. (2000) compare the distribution of nutrition levels across populations exposed to two different types of food stamp programs (see Bishop et al. 1996, 1992 for other applications to the distribution of nutrients). Fisher et al. (1998) compare the distribution of returns to US Treasury Bills of different maturities. Anderson (1996) compares pre- and post-tax income distributions in Canada over several years. Bishop et al. (1993) compare poverty distributions across ten countries, Klecan, McFadden and McFadden (1991) rank closed end mutual funds, and Davidson and Duclos (2000) provide poverty rankings based on Luxemburgh panel data.

More relevant to environmental issues, Maasoumi and Millimet (2001) conduct stochastic dominance tests on the distribution of toxic releases across US counties for various years over the period 1988 to 1999. Using data from the US EPA's Toxic Release Inventory (TRI), the authors find strong evidence of overall improvement in the distribution of releases over this time period. Building on this work, the questions we seek to answer in this paper are twofold. First, how does the unconditional and conditional distribution of toxic releases compare across white and nonwhite counties at a point in time? Second, does the improvement over time in the distribution of releases documented in Maasoumi and Millimet (2001) hold for both white and nonwhite counties? Examination of the first question provides a more revealing picture of the cross-sectional "association" between race and pollution levels than standard regression analysis. The latter seeks to understand if the benefits of improved environmental quality over time are shared by all, or only counties with few or small minorities.

The nonparametric tests of first and second order stochastic dominance (hereafter FSD and SSD, respectively) relations used to answer these questions have been utilized in McFadden (1989), Klecan et al. (1991), Kaur et al. (1994), Maasoumi and Heshmati (2000, 2001), and Maasoumi and Millimet (2001). The tests draw upon bootstrap techniques to assess the level of statistical confidence regarding various relations. The results are rather striking. While mean levels of both unconditional and conditional toxic releases are higher in nonwhite counties in most cases, the dominance tests reveal that such rankings are either not robust or not statistically significant. We find no statistically significant uniform ranking between the unconditional or conditional distributions of total, air, water, land, and underground releases across white and nonwhite counties in either 1990 or 1999. Moreover, in the majority of cases where environmental quality either improved (or worsened) during the 1990s, the improvements (or decline) occurred simulataneously in both white and nonwhite counties. These results based on data from the Toxic Release Inventory indicate that more data and rigorous statistical analysis is called for in order to examine claims of environmental discrimination.

The remainder of the paper is organized as follows. Section 2 defines the various dominance relations and describes the tests used to identify such relations in the data. Section 3 discusses the pollution data. Section 4 presents the results. Section 5 offers some concluding remarks.

Methodology

Several tests for stochastic dominance have been proposed. Maasoumi and Heshmati (2000) provide a brief review of the historical development of the various tests. Since the asymptotic distributions depend on the unknown true distributions, Monte Carlo implementation of the nonparametric tests for FSD and SSD utilized herein were first examined in McFadden (1989) and Klecan et al. (1991). McFadden (1989) assumes *iid* observations and independent variates. Klecan et al. (1991) allows for general weak dependence over time, and a general exchangeability between the variables (distributions) being ranked. Barry and Donald (2001) also assume *iid* observations and independent variates in deriving a supremum version of the tests. As in Maasoumi and Heshmati (2000), we utilize bootstrap techniques in order to apply these tests to analyse pollution distributions in the US.

To begin, let X and Y denote two pollution variables. In the empirical analysis, X (Y) may refer to pollution in 'white' ('nonwhite') counties at a point in time, or X (Y) may refer to pollution in counties of a certain composition at two points in time. $\{x_i\}_{i=1}^{N}$ is a vector of N strictly stationary, $\alpha-$ *mixing*, possibly *dependent* observations of X; $\{y_i\}_{i=1}^{M}$ is an analogous vector of realizations of Y. Let W_1 denote the class of decreasing social welfare functions w such that $w' \leq 0$, and W_2 the class of social welfare functions in W_1 such that $w'' \leq 0$ (i.e. strict concavity). Concavity indicates that one is averse to differential pollution levels across locations; high concentration of pollutants is undesirable. footnote Let $F(x)$ and $G(y)$ represent the unknown cumulative density functions (CDF) of X and Y, respectively, which are assumed to be continuous and differentiable. Finally, let $q_x(p)$ and $q_y(p)$ denote the p^{th} quantiles of each distribution, defined such that $\inf.\Pr\{X \leq q_x(p)\} = p$ for X (and likewise for Y).

Under this notation, and remembering that social welfare is decreasing in levels of pollution, the distribution of X weakly dominates Y in the first order sense (denoted as X FSD Y) if $E(w(X)) \geq E(w(Y))$, for all $w \in W_1$. E denotes expectation, and strict dominance requires strict inequality for at least some w. The empirically relevant conditions which are testable when one notes that, X FSD Y *iff*:

$$F(x) \geq G(x) \quad \forall x \in \aleph, \text{ (and strongly, with strict inequality for some } x). \qquad \#$$

For theoretical reasons, it is assumed that $\aleph$, the support of X and Y, is bounded. It is well known that the condition in (ref: eq:fsd1) is equivalent to the requirement that (e.g., see McFadden (1989):

$$q_x(p) \leq q_y(p) \quad \forall p \in [0,1], \text{ (and strongly, with strict inequality for some } p). \qquad \#$$

If X FSD Y, then the expected social welfare from distribution of X is at least as great as that from distribution of Y for all decreasing social welfare functions in the class W_1.

The distribution of X dominates Y in the second order sense (denoted as X SSD Y) *iff*

$$\int_{-\infty}^{x} F(t)dt \geq \int_{-\infty}^{x} G(t)dt \quad \forall x \in \aleph, \qquad \#$$

Condition (ref: eq:ssd1) may be equivalently expressed as

$$\int_0^p q_x(t)dt \leq \int_0^p q_y(t)dt \quad \forall p \in [0,1], \qquad \#$$

If X SSD Y, then the expected social welfare from X is at least as great as that from Y for all decreasing and strictly concave social welfare functions in the class W_2. Note that FSD implies SSD.

As in Maasoumi and Heshmati (2000), the McFadden-type tests for FSD and SSD are based on the empirical counterparts of (ref: eq:fsd1) and (ref: eq:ssd1). Basing test statistics on the empirical evaluations of (ref: eq:fsd1) and (ref: eq:ssd1) requires that the pollution levels be consistently estimated at a finite number of points over the support of the data. Specifically, the test for FSD requires (i) computing the values of $F(x_q)$ and $G(x_q)$ for x_q, $q = 1,...,Q$, where Q denotes a finite number of points on the support $\aleph$ that are utilized, (ii) computing the differences $d_1(x_q) = F(x_q) - G(x_q)$ and $d_2(x_q) = G(x_q) - F(x_q)$, and (iii) finding $d^* = \min\{\max\{d_1\}, \max\{d_2\}\}$. If $d^* < 0$ (to a degree of statistical certainty), then the null hypothesis of no first order dominance is rejected. Furthermore, if $d^* < 0$ and $\max\{d_1\} > 0$, then X FSD Y as the value of the CDF for distribution X is at least as great as the corresponding value for distribution Y at x_q, $q = 1,...,Q$; if $\max\{d_2\} > 0$ then Y FSD X. The analogous test for SSD requires (i) computing the values of $F(x_q)$ and $G(x_q)$ for the Q points in the support $\aleph$, (ii) computing the differences

d_1 and d_2, (iii) calculating the sums $d_{1q} = \sum_{i=1}^{q} d_1(x_i)$ and $d_{2q} = \sum_{i=1}^{q} d_2(x_i)$, $q = 1,...,Q$, and (iv) finding $d^{**} = \min\{\max\{d_{1q}\},\max\{d_{2q}\}\}$. If $d^{**} < 0$ (to a degree of statistical certainty), then the null hypothesis of no second order dominance is rejected. X SSD Y. Moreover, if $d^{**} < 0$ and $\max\{d_{1q}\} > 0$, then X SSD Y as the cumulative value of the CDF for distribution X exceeds the corresponding value for distribution Y at all x_q; otherwise, if $\max\{d_{2q}\} > 0$, then Y SSD X. We use the bootstrap method to estimate the probability that these two statistics take negative values in $B = 1000$ resamples. footnote

Dann: The following[..] won't do!:

[Given the equivalence between dominance conditions based on the quantiles (equations (ref: eq:fsd2) and (ref: eq:ssd2)) and those based on evaluations of the empirical CDFs, (equations (ref: eq:fsd1) and (ref: eq:ssd1)), there is an operationally equivalent method of computing the required probabilities based on the empirical evaluations of (ref: eq:fsd2) and (ref: eq:ssd2). This requires that the pollution levels are consistently estimated at a finite number of percentiles (say) of the data. To begin, compute the empirical distribution of pollution levels for $p = 0.01, 0.02, 0.03, ..., 0.99$. The test for FSD (of X over Y) requires (i) computing the values of $q_x(p)$ and $q_y(p)$ for the 99 values of p, (ii) computing the differences, $d(p) = q_y(p) - q_x(p)$, and (iii) finding $d^* = \min_p \{d(p)\}$. If $d^* \geq 0$, then X FSD Y as the level of pollution in distribution Y is at least as great as the corresponding level in distribution X at each p. The analogous test for SSD requires (i) computing the values of $q_x(p)$ and $q_y(p)$ for the 99 values of p, (ii) computing the differences, $d(p) = q_y(p) - q_x(p)$, (iii) calculating $d_t = \sum_{i=1}^{t} d(i/100)$, $t = 1,...,99$, and (iv) finding $d^{**} = \min_t \{d_t\}$. If $d^{**} \geq 0$, then X SSD Y. Similarly, one can then test if Y FSD (SSD) X. In the empirical section, we utilize this algorithm for the simple reason of computational ease.]

In the analysis below, we report the mean and standard deviation of each test statistic, in addition to the empirical probability that $d^* \geq 0$ and $d^{**} \geq 0$ (computed as the frequency – out of 1000 – that each test statistic is non-negative). We also report empirical p-values as estimated from the bootstrap distribution. One must note, hoever, the qualification in the last footnote.

The tests presented here contrast with early studies of distribution ranking that structured the null hypothesis in terms of the 'equality' of two distributions, rejection of which would produce an ambiguity between unrankable (crossing) as compared to 'equal' distributions. Specifying the null in terms of inequality in a particular direction implies that for any pairwise comparison between distributions, dominance relations in both directions must be tested.

Thus far X and Y have represented two unconditional distributions. Since race tends to be correlated with income and, as shown in the environmental Kuznets curve (EKC) literature and elsewhere, income is related to environmental quality (e.g. Grossman and Krueger 1995; Kahn and Matsuka 1997; Hilton and Levinson 1998), we also perform dominace tests on the conditional (on income) pollution distributions. This is accomplished by estimating a standard parametric EKC-type model on the full sample of all counties, obtaining the residuals, and performing the dominance tests on the residuals. Specifically, in the first-stage we estimate

$$\ln(p_{it}) = \alpha + \gamma_t + \sum_{j=1}^{3} \left[\ln(y_{it})\right]^j + \varepsilon_{it} \qquad \#$$

[DANN: Does this have other coefficients for incomes!?]

where p_{it} is a measure of releases in county i at time t, γ_t is a set of time invariant/fixed effects, y is a measure of income, and ε is assumed to be an *iid* error term. Upon estimation of (ref: eq:p), we construct the estimated residuals, $\hat{\varepsilon}_{it}$, and conduct dominance tests on the distribution of the residuals across the "races" at a point in time, and over time for each group. By netting out the effect of income, we are able to eliminate changes in the distribution of pollution over time due simply to economic growth, as well as eliminate cross-sectional differences in the pollution distribution across counties by race due to income differentials.

DANN: So, in a sense the unconditional (on incomes) comparisons between the races, are conditional by race. If one finds dominance in this latter case, the conclusion is that INCOME is the important indicator of county pollution. Do we find this?

Data

The pollution data are obtained from the EPA's Toxic Release Inventory (TRI). With the passage of the Emergency Planning and Community Right-to-Know Act (EPCRA) in 1986, manufacturing facilities (designated as Standard Industrial Classification (SIC) 20 – 39) are required to release information on the emission of over 650 toxic chemicals and chemical categories. footnote In addition, facilities are required to report the quantities of chemicals which are recycled, treated, burned, or disposed of in any other manner either on-site or off-site. Any facility which produces or processes more than 25,000 pounds or uses more than 10,000 pounds of any of the listed toxic chemicals must submit a TRI report (US EPA 1992). The data are currently available from 1988 – 1999, and for the present analysis are aggregated to the county level.

While the toxic release data are available at the chemical level, the data are aggregated into several broad categories so that the number of dominance tests is manageable. The categories are air, land, water, and underground releases (for definitions refer to Appendix A). In the majority of studies utilizing the TRI data, these four pollution categories are aggregated together as well.

Although these aggregations give equal weight to each chemical, some studies have been concerned about forming new aggregates, weighting each chemical by a measure of toxicity (Brooks and Sethi 1997; Arora and Cason 1995). However, as reported by the EPA, most of the widely used chemicals do not vary significantly in their toxicity and many of the less toxic chemicals have not been assigned risk scores by the EPA (Arora and Cason 1999; US EPA 1989). Nonetheless, Arora and Cason (1995) perform their analysis weighting each chemical equally as well as weighting chemicals by risk scores (when available). The authors find their results to be robust to the choice of aggregation scheme.

To compare the distribution of releases across various years, one must be ensure that releases are measured consistently. However, the list of chemicals firms are required to report to the EPA is constantly being amended. Firms were required to report the release of 337 chemicals during the first year, 1988. Under EPCRA any citizen has the right to petition the EPA to add or remove chemicals from the required list. While minor additions and deletions are made virtually every year, 286 new chemicals were added beginning in 1995. The additional chemicals were derived from other environmental statutes: the 1990 Clean Air Act Amendments, the Clean Water Act, and California's 1986 Safe Drinking Water and Toxic Enforcement Act (Terry and Yandle 1997). The basis for the decision to add these chemicals is given in EPCRA section 313(d)(2). Specifically, the chemicals must pose "acute human health risks, cancer or chronic (non-cancer) human health effects, and/or environmental effects." footnote In addition, the list of industries required to submit TRI reports to the EPA was expanded in 1998. footnote To ensure compatibility when making time series comparisons, we do not incorporate pollution data from the new industries added in 1998. In the terminology of the EPA, we restrict our analysis to the "original industries." To handle the massive expansion of the TRI chemicals in 1995, we utilize two different sets of TRI data: (i) all TRI reported releases and (ii) releases of only 1988 core chemicals (i.e. the 337 original named chemicals). In other words, for each county-year observation, we utilize data on the releases of all chemicals required at that time (denoted as "all chemical"), as well as releases at that time of only those chemicals that were on the original list of required chemicals in 1988 (denoted as "1988 chemicals").

The emissions data are combined with county population data (total and by race) obtained from the Census Bureau. In addition, the Bureau of Economic Analysis provides annual data on the average wage per job. While this is not a perfect measure of per capita income – the usual independent variable in EKC models – presumably the two are highly correlated since wages tend to be the primary component of total income. Figure 1 plots mean total and air releases over time for 'white' and 'nonwhite' counties, for both aggregate (Panels A and C) and per capita releases (Panels B and D). footnote Panels A and B use all chemicals reported in each year, while Panels C and D use only the 1988 original core chemicals. According to Panels A and B, mean total releases (aggregate or per capita) tend to be much higher in nonwhite counties; air releases are more equalized. Restricting attention to only the original 1988 chemicals, mean per capita levels of total releases remain higher in nonwhite counties; mean aggregate levels of total releases do not different substantially by racial composition. However, as stated previously, drawing conclusions based on simple statistics – such as the mean – may be potentially misleading to the extent that such statistics provide little information pertaining to changes in the entire distribution of toxic releases.

So as not overwhelm the reader, we provide the results from only a subset of all possible tests. For each of the five pollution categories (air, water, land, underground, and total releases), we compare the distribution of releases across white and nonwhite counties using two cross-sections of data: 1990 and 1999. Next, to examine if the improvements over time in the distribution of releases holds for both white and nonwhite counties, we compare the distribution in 1999 to 1990 for white counties and then for nonwhite counties. For the time series comparisons, we perform each *conditional* test twice, once using all chemicals and once only the original 1988 core chemicals. However, for the cross-sectional comparisons and the *conditional* time series comparisons we use all chemicals reported in 1990 and 1999. For the cross-sectional comparisons, there clearly is no comparability issue. For the conditional time series comparisons, the inclusion of time fixed effects in the equation (ref: eq:p) will net out differences over time due to the changing list of chemicals included under the TRI doctrine.

Results

The dominance and bootstrap results for the unconditional distributions of total toxic releases (using all reported chemical releases) are provided in Table 1. The unconditional test results based only on the distribution of the original set of 1988 chemicals are relegated to Appendix B, Table B1. Table 2 presents the conditional dominance test results for total releases (using all reported chemical releases). Tables 3 – 10 display the analagous results for the individual emission types. The first-stage results used to construct the conditional distributions are given in Appendix C, Table C1. We note that for all types of pollutants average wages (and the higher order terms) are statistically significant determinents of toxic releases (both per capita and aggregate). In addition, the cubic specification generates an inverted U-shaped relationship between each pollution type and average wages, consonant with the EKC literature.

In Tables 1 – 10, the top of each table displays the summary statistics, with the remainder of the table containing the dominance results. For each pairwise comparison of distributions, the column labelled **Observed** reports a "Yes" if the actual observed distribution dominates (in either a first- or second-degree sense) the distribution it is being compared with; "No" otherwise. A "Yes" for a test of FSD (SSD) indicates that the empirical value of d^{*} (d^{**}) is

The column labelled **Mean** and **Standard Deviation** reports the mean and standard deviation of the 1000 bootstrapped values of d^{*} or d^{**}. Finally, the column labelled **Prob** lists the p-value associated with the null hypothesis that the first distribution dominates the second. Thus, a p-value greater than 0.95 (or 0.90) is interpreted as statistically significant evidence of dominance.

Cross-Sectional Comparisons

1990 Results

Plots of the unconditional cumulative distributions for total releases by race for 1990 are presented in Figure 2 (Panels A and B), with the distributions of aggregate emissions presented in Panel A and the distributions of per capita releases displayed in Panel B. footnote Visual inspection reveals that, for both aggregate and per capita releases, the CDFs for nonwhite counties lie to the left of the CDFs for white counties over most of the support of the distributions, implying lower pollution levels in minority-dominated counties. This examination of the entire empirical distribution offers a different conclusion regarding the presence of environmental discrimination than a simple comparison of (unconditional) mean total releases by race. As shown at the top of Table 1, mean aggregate total releases are 24% greater in nonwhite counties; mean per capita releases over 200% higher in nonwhite counties.Utilizing the complete distribution implies that the comparisons based on the (arithmatic) means may be driven by a few outliers. Clearly, certain indices, implied by welfare functions especially penalizing pollution in, or weighting only these outliers, would give complete and decisive ranking of environmental states by race.

The conditional CDFs for total releases are plotted in Figure 3 (Panel A for aggreaget releases and Panel B for per capita releases). In contrast to the unconditional distributions displayed in Panels A and B of Figure 2, the conditional CDFs for white counties lie to the the left of the conditional CDFs for nonwhite counties over much of the support. Unlike the unconditional results, however, insights gained through a simple comparison of conditional means are consonant with the distribution plots in Figure 3. Specifically, displayed at the top of Table 2, the conditional mean of aggregate (per capita) total releases are 12% (over 100%) greater in nonwhite counties.

Inferences obtained through visual inspection of the CDF plots in Figures 2 and 3 do not offer any measure of statistical certainty. Thus, we now turn to the actual dominance tests and bootstrap results. The first set of dominance test results in Table 1 indicate that there does not exist any unambiguous ranking between the distributions of total releases – either aggregate or per capita – across white and nonwhite counties in 1990. The lack of an unambiguous welfare ordering is just as informative as if we had been able to rank the distributions. In particular, the results imply that any claim of unconditional pollution levels being 'worse' in locations inhabited by a greater concentration of minorities is specific to the particular ranking criteria (and underlying social welfare function) being utilized; the result is not robust to the choice of social welfare function among the class defined by W_1 and W_2 described previously.

As alluded to earlier, the large literature on the environmental Kuznets curve documents an inverted U-shaped relationship with respect to income for many types of environmental hazards. According to the first-stage results presented in Appendix C, there does exist an inverted U-shaped relationship between average county wages and aggregate and per capita total releases. The peak of the relationships – for both aggregate and per capita levels – occur at an average wage of roughly \$29,000 (there is also a local minimum at \$7,500). The mean average wage across white counties is approximately \$19,500; \$19,300 in nonwhite counties. The fact that white counties receive higher average wages and that income and total releases are positively correlated over this range of wages leads one to suspect that ceteris paribus pollution levels should be higher in white counties. The lack of statistical evidence supporting such a dominance ordering suggests the need to control for income differences. In other words, it may be that the additional pollution generated in white counties with higher wages is offset by environmental discrimination favoring these same counties, leading to a failure to detect any unambiguous ordering of the unconditional distributions.

To test this claim, we conduct dominance tests on the residuals from the first-stage regression (i.e., on the conditional distributions). The results, reported in Table 2, indicate that there is no statistical evidence supporting an unambiguous ranking of the distributions. Thus, even controlling for the effects of income differentials, any claims of the distribution of total releases being 'better' or 'worse' in white versus nonwhite counties would be very subjective, and specific only to the particular social welfare function being implicity utilized.

The 1990 cross-sectional results for each of the individual pollution types are displayed in Tables 3 – 10. Tables 3 and 4 present the unconditional (Table 3) and conditional (Table 4) results for toxic air releases. Since air releases constitute the largest share of total releases, the results are very similar to the results for total releases displayed in Tables 1 and 2. The one noticeable difference occurs in Table 3. In the actual data, the unconditional distribution of air releases in nonwhite counties is found to dominate in a second-degree sense the distribution in white counties. However, as the bootstrap p-value is only 0.67, this finding is not statistically significant. This illustrates the importance of using bootstrap or alternative techniques to assess the statistical confidence of any findings. The conditional dominace tests yield no substantive differences between air and total releases. Consequently, we are not able to unambiguously rank the distribution of air releases across white and non-white counties in 1990.

Table 5 and 6 present the results for toxic water releases; Tables 7 and 8 display the results for toxic land releases. In all cases – unconditional or conditional tests, using aggregate and per capita measures – we are not able to unambiguously rank the distributions. Thus, as with total and air releases, any claims of lower environmental quality in nonwhite counties should not be considered robust to the choice of comparison index.

Finally, for underground toxic releases, we do find, visually, that the *sample* unconditional distribution of aggregate releases in white counties appears to dominate in a first-degree sense (and, hence, second-degree sense as well) the corresponding distribution in nonwhite counties. As before, however, this finding is not statistically significant in either the first- or second-degree sense (FSD: p=0.42; SSD: p=0.46).

To summarize, then, despite the fact that mean unconditional and conditional releases are higher – in aggregate and per capita terms – for total releases and the majority of the individual pollution types in nonwhite counties, consideration of the entire distribution fails to yield such unambiguous rankings. To determine if this conclusion remains valid using more recent data, we now turn to the analysis using the 1999 TRI data.

1999 Results

Plots of the unconditional cumulative distributions for total releases by race for 1999 are presented in Figure 2 (Panels C and D). footnote Visual inspection reveals that, for both aggregate and per capita releases, the CDFs for nonwhite counties lie to the left of the CDFs for white counties, although both the aggregate and per capita distributions are more 'similar' in 1999 relative to 1990 across white and nonwhite counties (i.e. in Panels C and D as opposed to Panels A and B). As shown at the top of Table 1, mean aggregate and per capita total releases are much higher in nonwhite counties despite the fact that the distributions appear to favor nonwhite counties over the majority of the support. Thus, as in the previous section, inspection of the full distribution offers a different picture than that yielded by a simple comparison of the first moments. Moreover, the fact that the CDFs are more 'similar' in 1999 may suggest some type of convergence in pollution levels across locations of different racial composition. footnote In addition, the absolute racial gap defined as a function of the first moments has fallen by approximately 80% since 1990 (in both aggregate and per capita terms), again consistent with the notion of convergence in pollution levels. footnote

The conditional CDFs for total releases in 1999 are plotted in Figure 3 (Panels C and D for aggregate and per capita releases, respectively). As in 1990, the conditional CDFs for white counties lie to the the left of the conditional CDFs for nonwhite counties over much of the support. Visually, the conditional distributions also appear marginally 'closer' in 1999 relative in 1990, perhaps suggesting convergence in conditional releases as well. As for the conditional mean pollution levels, as in the previous section for 1990, the conditional means are higher in nonwhite counties. Specifically, aggregate (per capita) total releases are 10% (42%) greater in nonwhite counties. As these percentages are smaller than in 1990, this may be further evidence of convergence in conditional pollution levels.

Turning to the actual dominance tests and bootstrap results, Table 1 indicates that there is no unambiguous ranking between the distributions of aggregate or per capita total releases across white and nonwhite counties in 1999. As with the 1990 results, the lack of such a relationship is insightful, implying that any claim of unconditional pollution levels being 'worse' in locations inhabited by a greater concentration of minorities is not robust. Examining the distributions conditional on average wages (Table 2), we do find that the observed conditional per capita distribution in white counties second order dominates the conditional distribution in nonwhite counties. However, this finding is not statistically significant (p=0.79), and there is no such observed ranking using the distributions of aggregate emissions.

In terms of air (Tables 3 and 4), water (Tables 5 and 6), and land (Tables 7 and 8) releases in 1999, the results are qualitatively identical to the 1990 results. First, the unconditional distribution of aggregate air releases in nonwhite dominates in a second-degree sense the equivalent distribution in white counties, but the result is statistically insignificant (p=0.50). Second, the unconditional distributions of water and land releases – either aggregate or per capita – are unrankable, as are the conditional distributions. Consequently, as in 1990, there no unambiguous statements may be made concerning the relative environmental quality (measured by toxic releases) of white versus nonwhite counties.

For underground releases (Tables 9 and 10), several differences between the 1999 and 1990 results emerge. In 1990 the aggregate distribution of unconditional releases in white counties first order dominates the distribution in nonwhite counties, although the results are statistically insignificant. In 1999 the reverse holds; the unconditional aggregate distribution in *nonwhite* counties dominates in a first-degree sense the equivalent distribution in white counties. Again, however, the results are not statistically significant (FSD: p=0.65; SSD: p=0.65). While not statistically significant, the reversal of observed rankings is interesting and perhaps signals greater improvements in the relative quality of nonwhite counties in the future. In terms of unconditional per capita releases, whereas we found no unambiguous rankings in 1990, in 1999 the distribution in nonwhite counties first order dominates the distribution in white counties; although, as with the aggregate releases, the results are not statistically significant (FSD: p=0.72; SSD: p=0.72). Finally, as in 1990, there does not exist any unambiguous rankings for the conditional distributions of underground releases.

In the end, then, despite the fact that mean unconditional and conditional releases continue to be higher – in aggregate and per capita terms – for total releases and most of the individual pollution types in nonwhite counties, more robust tests based on stochastic dominance do not offer any unambiguous rankings. Moreover, while not statistically significant, most instances where the observed distributions can be ranked indicate superior environmental quality in counties concentrated with nonwhite individuals. As a final means of searching for some robust relationships concerning race and environmental quality, however, we turn to time series comparisons of pollution distribution. Whereas Maasoumi and Millimet (2001) demonstrate that more recent distributions of toxic releases tend to dominate older distributions (pooling all counties regardless of racial composition), we examine whether such unambiguous improvements hold for both white and nonwhite counties.

Time-Series Comparisons

White Counties

Tables 1 and 2 report the unconditional and conditional results for total toxic releases, respectively, where the tests compare the 1999 distribution in white (nonwhite) counties with the 1990 distribution in white (nonwhite) counties. The unconditional results in Table 1 are based on the full set of chemicals reported under the TRI in each year. Since, as stated previously, the number of chemicals falling under the TRI guidelines in 1999 is virtually twice the number from 1990, the tests should be 'biased' toward a finding of either no dominance, or even 'better' environmental quality in 1990. To the contrary, as displayed in Table 1, the unconditional distributions – aggregate and per capita – in white counties in 1999 are observed to first order dominate the 1990 distributions in white counties. For nonwhite counties, the 1999 aggregate distribution is observed to first order dominate the 1990 distribution, but the 1999 per capita distribution is only observed to dominate the 1990 distribution in a second-degree sense. Furthermore, while the findings of FSD in white counties are statistically significant (aggregate: p=1.00; per capita: p=1.00), even the findings of SSD are not statistically significant for nonwhite counties (aggregate: p=0.59; per capita: p=0.65). Finally, for completeness, Table C1 in the Appendix displays the unconditional dominance results using only the original 1988 TRI chemicals. The results are unchanged qualitatively.

The conditional results shown in Table 2 indicate that the 1999 distributions –aggregate and per capita – second order dominate the 1990 distributions for both white and nonwhite counties, and all findings are statistically significant (white: p=1.00 for both aggregate and per capita; nonwhite: p=0.97 for aggregate, p=1.00 for per capita). Consequently, while only the unconditional improvements in the release of toxic chemicals in white counties over the 1990s are statistically significant, controlling for average wages reveals that all counties – regardless of racial composition – have experienced comparable welfare improvements from the reduction in releases.

The results for toxic air releases are displayed in Table 3 – 4 and Table C1 in the Appendix. The dominance results differ very little from the results for total releases. In particular, the unconditional distributions (using all TRI chemicals) of both aggregate and per capita releases in 1999 first order dominate their respective 1990 counterparts in white counties. The FSD findings are statistically significant. For nonwhite counties, both 1999 distributions dominate their equivalent 1990 distributions in the second-degree sense, but niether result is statistically significant. Moreover, as with total releases, the unconditional results are unchanged if we use only the original 1988 chemicals (Table C1). Lastly, the conditional results are also identical to the conditional results for total releases; all 1999 distributions second order dominate their 1990 counterparts, and the results are statistically significant.

For water releases, there does not exist any unambiguous ranking between the aggregate or per capita unconditional distributions in 1999 and 1990 for either white or nonwhite counties (Table 5). Furthermore, even if we restrict the analysis to only the original 1988 chemicals, the qualitative results remain unchanged, although we do find that the observed 1999 distribution of aggregate releases second order dominates the 1990 distribution in white counties (but the finding is not statistically significant (p=0.38)). We also fail to find any unambiguous ranking between the various 1999 and 1990 conditional distributions (Table 6). As a result, while air and total toxic releases have unambiguously improved in a social welfare sense during the 1990s, particularly in white counties and conditional on average wages, no such statements can be made concerning water releases. However, despite the lack of improvement in the release of toxics in the water, this lack of improvement is not concentrated in counties heavily populated by minorities.

In terms of land releases, the unconditional results are very similar to the unconditional results for water releases. In particular, there exist no unambiguous rankings between the aggregate or per capita 1999 and 1990 distributions in either white or nonwhite counties (Table 7). In addition, the lack of uniform rankings is unaltered when we restrict the analysis to only the original 1988 TRI chemicals (Table C1). The conditional dominance tests for land releases, however, are more encouraging (Table 8). For white counties, the 1999 aggregate and per capita distributions are found to second order dominate the 1990 distributions, and the results are statistically significant (aggregate: p=1.00; per capita: p=1.00). For nonwhite counties, while the observed 1999 aggregate and per capita distributions are observed to second order dominate the 1990 distributions, only the former is statistically significant (aggregate: p=1.00; per capita: p=0.55). Consequently, as in the case of air and total releases, we find strong evidence indictaing unambiguous welfare improvements in the distributions of land releases conditional on average wages. Moreover, these improvements are not confined solely to white counties.

The dominance tests for underground toxic releases are interesting. Tables 9 and C1 indicate that the unconditional distributions in 1999 (both aggregate and per capita as well as utilizing all chemicals or only the 1988 original TRI chemicals) are observed to first order dominate the 1990 distributions for both white and nonwhite counties. Moreover, these uniform rankings are statistically significant at the 95% confidence level in all cases for white counties. For nonwhite counties, the result using the per capita distribution of all TRI chemicals is also statistically signficant at the 95% confidence level. However, the result using the aggregate distribution of all TRI chemicals is only significant at the 90% confidence level and the unconditional results – aggregate and per capita – using only the 1988 chemicals are statistically insignificant at conventional levels. On the other hand, when we turn to the conditional dominance tests (Table 10), the results are reversed. Conditional on average wages, the 1990 aggregate and per capita distributions in both white and nonwhite counties first order dominate the respective 1999 distributions. The results are all statistically significant at the 99% confidence level as well. While the conditional results may be surprising, in terms of the interaction between racial composition and pollution levels there is no difference across white and nonwhite counties.

Finally, given that the air (and land) releases have uniformly improved conditional on average wages over the 1990s and water and underground releases have either remained unchanged or uniformly worsened may be indicative of the reduced visibility of the latter releases. In any event, the results provided herein perhaps indicate that environmental policy should give increasing attention to water and underground releases.

Conclusion

For numerous decades, policymakers, environmental advocates, and minority leaders have been concerned about the spatial distribution of environmental quality (or lack thereof). At the risk of generalizing an enormous body of literature, evidence of such environmental racism or discrimination is typically documented through statistics based on the first and perhaps second moment of the unconditional or conditional distribution. For example, mean comparisons utilize only the first moment of the unconiditional distribution and regression analysis reports the mean impact of changes in racial composition conditional on other controls included in the model. The use of such index statistics is simplistic in that it ignores information contained in the remainder of the distribution. Furthermore, the (implicit) welfare underpinnings of such index statistics and the robustness of the results they imply are not made clear.

Addressing these concerns, we adapt recent developments for the analysis of income distributions in an attempt to reach some robust conclusions regarding not only the trend in environmental quality in the US, but also the relative quality of the environment of locations that differ in terms of their racial compostion. These developments, based on the concept of stochastic dominance, are nonparametric and utilize information on the entire distribution of pollution. Moreover, through the use of bootstrap techniques, we are able to report the results of the dominance tests to a degree of statistical certainty. Thus, a finding of a first- or second-degree dominance is extremely powerful, implying that any social welfare function that is decreasing in pollution levels (FSD) or decreasing, but at a decreasing rate (SSD), will prefer one distribution over another.

Using data from the EPA's Toxic Release Inventory from 1990 – 1999 at the county level, and dividing counties into those with more than 50% white population (denoted as 'white') or less than 50% (denoted as 'nonwhite'), we conduct three sets of dominance tests. First, we test if the unconditional distribution in white (nonwhite) counties dominates – either first or second order – the unconditional distribution in nonwhite (white) counties at a point in time. Second, building on the work in Maasoumi and Millimet (2001) that shows that more recent distributions (pooling all counties together) of pollution in the US dominate earlier distributions, we test if these improvements apply equally to white and nonwhite counties. Finally, we utilize conditional dominance tests by re-conducting the previous tests on the residuals from a parametric model controlling for the effect of cross-sectional income differentials and time-series income growth. The conditional dominance tests allow us to potentially rank the distribution of pollution controlling for the effects of income.

The results are surprising. While mean levels of both unconditional and conditional toxic releases tend to be greater in nonwhite counties, the dominance tests reveal that such rankings are not robust and/or statistically significant. We find no statistically significant uniform ranking between the unconditional or conditional distributions of total, air, water, land, and underground releases across white and nonwhite counties in either 1990 or 1999. Moreover, in the majority of cases where environmental quality either improved (or worsened) during the 1990s, the improvements (or decline) occurred simulataneously in both white and nonwhite counties. These results provided herein using data from the Toxic Release Inventory indicate that more rigorous statistical analysis is perhaps needed to justify claims of environmental discrimination.

bibitem Anderson, G. (1996), "Nonparametric Tests of Stochastic Dominance in Income Distributions," *Econometrica*, 64, 1183-1193.

bibitem Arora, S. and T.N. Cason (1995), "An Experiment in Voluntary Environmental Regulation: Participation in EPA's 33/50 Program," *Journal of Environmental Economics and Management*, 28, 271-286.

bibitem Arora, S. and T.N. Cason (1999), "Do Community Characteristics Influence Environmental Outcomes? Evidence from the Toxic Release Inventory," *Southern Economic Journal*, 65, 691-716.

bibitem Bishop, J.A., J.P. Formby, and L.A. Zeager (1992), "Nutrition and Nonparticipation in the US Food Stamp Program," *Applied Economics*, 24, 945-949.

bibitem Bishop, J.A., J.P. Formby, and W.J. Smith (1993), "International Comparisons of Welfare and Poverty: Dominance Orderings for Ten Countries," *Canadian Journal of Economics*, 26, 707-726.

bibitem Bishop, J.A., J.P. Formby, and L.A. Zeager (1996), "Relative Undernutrition in Puerto Rico Under Alternative Food Assistance Programs," *Applied Economics*, 28, 1009-1017.

bibitem Bishop, J.A., J.P. Formby, and L.A. Zeager (2000), "The Effect of Food Stamp Cashout on Undernutrition," *Economics Letters*, 67, 75-85.

bibitem Brooks, N. and R. Sethi (1997), "The Distribution of Pollution: Community Characteristics and Exposure to Air Toxics," *Journal of Environmental Economics and Management*, 32, 233-250.

bibitem Fisher, G., D. Wilson, and K. Xu (1998), "An Empirical Analysis of Term Premiums Using Significance Tests for Stochastic Dominance," *Economics Letters*, 60, 195-203.

bibitem Gelobter, M. (1992), "Toward a Model of 'Environmental Discrimination'," in B. Bryant and P. Mohai (eds.), *Race and the Incidence of Environmental Hazards*, Boulder, CO: Westview Press.

bibitem Grossman, G. and A.B. Krueger (1995), "Economic Growth and the Environment," *Quarterly Journal of Economics*, 33, 53-77.

bibitem Hilton, F. and A. Levinson (1998), "Factoring the Environmental Kuznets Curve: Evidence from Automotive Lead Emissions," *Journal of Environmental Economics and Management*, 35, 126-141.

bibitem Holtz-Eakin, D. and T.M. Selden (1995), "Stoking the Fires? CO_2 Emissions and Economic Growth," *Journal of Public Economics*, 57, 85-101.

bibitem Kahn, M. (1997), "Particulate Pollution Trends in the United States," *Regional Science and Urban Economics*, 27, 87-107.

bibitem Kahn, M. (1999), "The Silver Lining of Rust Belt Manufacturing Decline," *Journal of Urban Economics*, 46, 360-376.

bibitem Kahn, M.E. and J.G. Matsusaka (1997), "Demand for Environmental Goods: Evidence from Voting Patterns on California Initiatives," *Journal of Law and Economics*, 40, 137-173.

bibitem Kaur, A., B.L.S. Prakasa Rao, and H. Singh (1994), "Testing for Second-Order Stochastic Dominance of Two Distributions," *Econometric Theory*, 10, 849-866.

bibitem Klecan, L., R. McFadden, and D. McFadden (1991), "A Robust Test for Stochastic Dominance," working paper, Department of Economics, MIT.

bibitem List, J.A (1999), "Have Air Pollutant Emissions Converged? Evidence From Unit Root Tests," *Southern Economic Journal*, 66, 144-155.

bibitem Maasoumi, E. and A. Heshmati (2000), "Stochastic Dominance Amongst Swedish Income Distributions," *Econometric Reviews*, 19, 287-320.

bibitem Maasoumi, E. and D.L. Millimet (2001), "Stochastic Dominance Amongst U.S. Pollution Distributions," manuscript, Southern Methodist University.

bibitem McFadden, D. (1989), "Testing for Stochastic Dominance," in Part II of T. Fomby and T.K. Seo (eds.) *Studies in the Economics of Uncertainty* (in honor of J. Hadar), Springer-Verlag.

bibitem Schmalensee, R., T.M. Stoker, and R.A. Judson (1998), "World Carbon Dioxide Emissions: 1950 – 2050," *Review of Economics and Statistics*, 80, 15-27.

bibitem Terry, J.C. and B. Yandle (1997), "EPA's Toxic Release Inventory: Stimulus and Response," *Managerial and Decision Economics*, 18, 433-441.

bibitem U.S. Environmental Protection Agency (1989), *Toxic Chemical Release Inventory Screening Guide*, Volume 2, Washington, D.C.: Office of Toxic Substance, EPA.

bibitem U.S. Environmental Protection Agency (1992), *Toxic Chemical Release Inventory: Reporting Form R and Instructions*, Revised 1991 version, Washington, D.C.: EPA.

Appendix

Pollution Definitions

Definitions of the various pollution categories (available at http://www.scorecard.org).

¾ **Air Releases**

Total releases to air include all TRI chemicals emitted by a plant from both its smoke stack(s) as well "fugitive" sources (such as leaking valves).

Stack Air Releases.

Releases to air that occur through confined air streams, such as stacks, vents, ducts or pipes. Sometimes called releases from a point source.

Fugitive Air Releases.

Releases to air that do not occur through a confined air stream, including equipment leaks, evaporative losses from surface impoundments and spills, and releases from building ventilation systems. Sometimes called releases from nonpoint sources.

¾ **Water Releases**

Releases to water include discharges to streams, rivers, lakes, oceans and other bodies of water. This includes releases from both point sources, such as industrial discharge pipes, and nonpoint sources, such as stormwater runoff, but not releases to sewers or other off-site wastewater treatment facilities. It includes releases to surface waters, but not ground water.

¾ **Land Releases**

Land releases include all the chemicals disposed on land within the boundaries of the reporting facility, and can include any of the following types of on-site disposal:

RCRA Subtitle C Landfills

Wastes which are buried on-site in landfills regulated by RCRA Subtitle C.

Other On-site Landfills

Wastes which are buried on-site in landfills that are not regulated by RCRA.

Land Treatment/ Application Farming

Wastes which are applied or incorporated into soil.

Surface Impoundments

Surface impoundments are uncovered holding ponds used to volatilize (evaporate wastes into the surrounding atmosphere) or settle waste materials.

Other Land Disposal

Other forms of land disposal, including accidental spills or leaks.

¾ **Underground Injection**

Underground injection releases fluids into a subsurface well for the purpose of waste disposal. Wastes containing TRI chemicals are injected into either Class I wells or Class V wells:

Class I Injection Wells

Class I industrial, municipal, and manufacturing wells inject liquid wastes into deep, confined, and isolated formations below potable water supplies.

Other Injection Wells

Include Class II, III, IV, and V wells. Class II oil- and gas-related wells re-inject produced fluids for disposal, enhanced recovery of oil, or hydrocarbon storage. Class III wells are associated with the solution mining of minerals. Class IV wells may inject hazardous or radioactive fluids directly or indirectly into underground sources of drinking water (USDW), only if the injection is part of an authorized CERCLA/RCRA clean-up operation. Class V wells are generally used to inject non-hazardous wastes into or above an underground source of drinking water. Class V wells include all types of injection wells that do not fall under I – IV. They are generally shallow drainage wells, such as floor drains connected to dry wells or drain fields.

Additional Results

Table B1. Unconditional Stochastic Dominance Tests by Racial Composition: 1988 Chemicals Only.

Tests		Aggregate				Per Capita			
		Obs.	Mean	Std Dev	Prob	Obs.	Mean	Std Dev	Prob
Total	FSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	-0.14	1.61	p=0.99
	FSD: W_{90} over W_{99}	No	-4.04E+06	8.93E+05	p=0.00	No	-48.62	16.16	p=0.00
	SSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	0.00	0.00	p=1.00
	SSD: W_{90} over W_{99}	No	-2.66E+07	2.20E+06	p=0.00	No	-334.47	38.11	p=0.00
	FSD: NW_{99} over NW_{90}	Yes	-1.31E+06	3.86E+06	p=0.36	No	-32.84	33.27	p=0.11
	FSD: NW_{90} over NW_{99}	No	-1.10E+07	7.55E+06	p=0.00	No	-853.18	1.33E+03	p=0.00
	SSD: NW_{99} over NW_{90}	Yes	-6.87E+05	2.94E+06	p=0.78	Yes	-18.03	47.43	p=0.73
	SSD: NW_{90} over NW_{99}	No	-2.63E+07	1.65E+07	p=0.00	No	-1.04E+03	1.44E+03	p=0.00
Air	FSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	0.00	0.00	p=1.00
	FSD: W_{90} over W_{99}	No	-3.43E+06	6.15E+05	p=0.00	No	-48.76	12.63	p=0.00
	SSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	0.00	0.00	p=1.00
	SSD: W_{90} over W_{99}	No	-2.41E+07	1.74E+06	p=0.00	No	-319.90	29.81	p=0.00
	FSD: NW_{99} over NW_{90}	No	-1.36E+06	3.76E+06	p=0.16	No	-49.98	40.40	p=0.02
	FSD: NW_{90} over NW_{99}	No	-7.57E+06	1.01E+07	p=0.00	No	-48.78	78.66	p=0.00
	SSD: NW_{99} over NW_{90}	Yes	-9.94E+05	3.39E+06	p=0.70	Yes	-24.53	50.61	p=0.64
	SSD: NW_{90} over NW_{99}	No	-1.42E+07	1.33E+07	p=0.00	No	-138.53	87.01	p=0.00
Water	FSD: W_{99} over W_{90}	No	-6.30E+03	7.20E+03	p=0.14	No	-0.32	0.44	p=0.08
	FSD: W_{90} over W_{99}	No	-2.99E+04	2.34E+04	p=0.00	No	-0.31	0.37	p=0.00
	SSD: W_{99} over W_{90}	Yes	-3.50E+03	9.19E+03	p=0.38	No	-0.26	0.48	p=0.28
	SSD: W_{90} over W_{99}	No	-5.51E+04	3.64E+04	p=0.00	No	-0.72	0.55	p=0.00
	FSD: NW_{99} over NW_{90}	No	-4.07E+04	3.03E+04	p=0.03	No	-2.77	1.47	p=0.01
	FSD: NW_{90} over NW_{99}	No	-4.67E+04	4.43E+04	p=0.03	No	-0.41	0.70	p=0.02
	SSD: NW_{99} over NW_{90}	No	-9.20E+04	9.94E+04	p=0.17	No	-5.24	3.56	p=0.04
	SSD: NW_{90} over NW_{99}	No	-6.54E+04	9.20E+04	p=0.07	No	-0.43	0.70	p=0.07

Table B1 (cont.). Unconditional Stochastic Dominance Tests by Racial Composition: 1988 Chemicals Only.

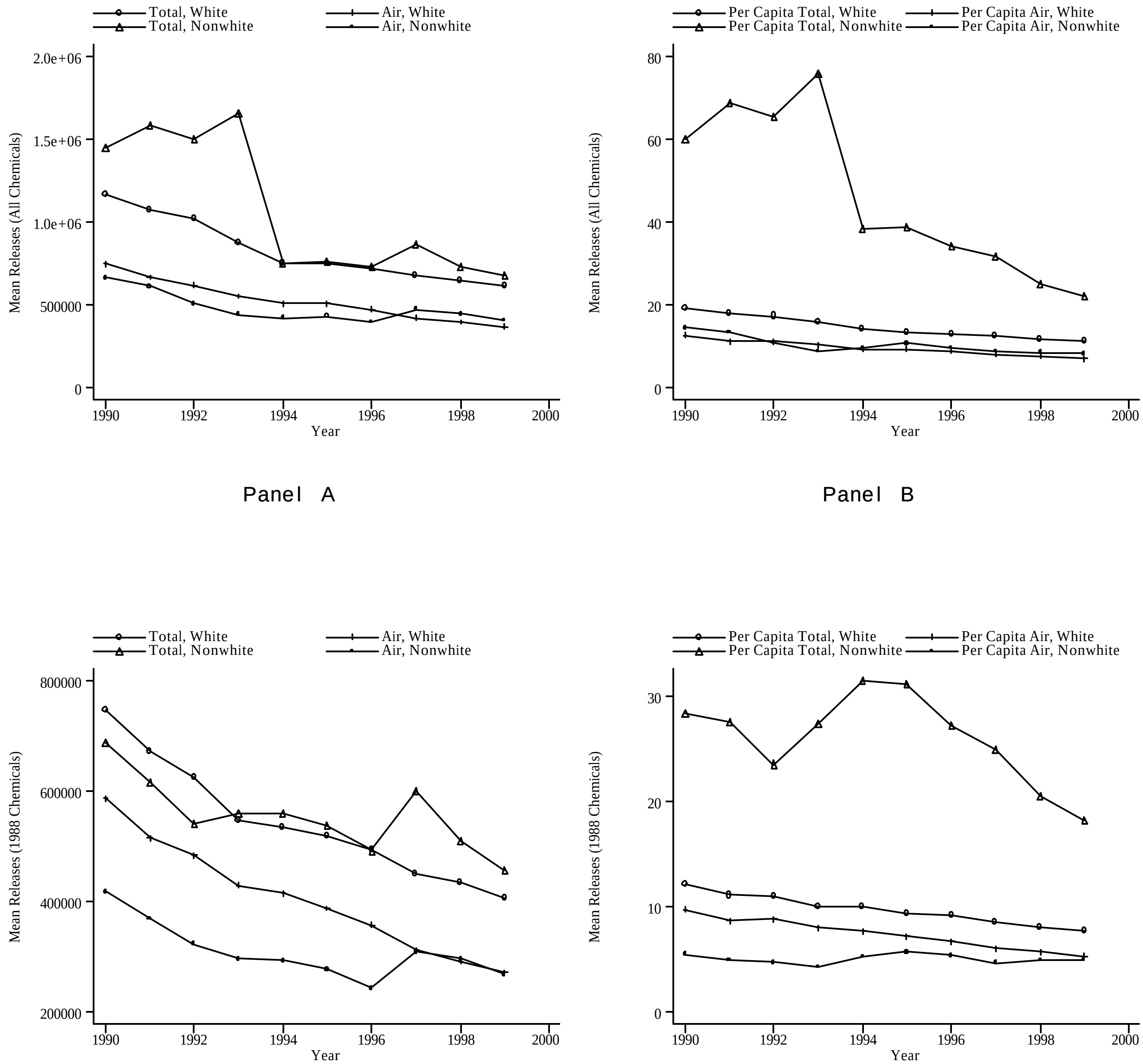
Tests		Aggregate				Per Capita			
		Obs.	Mean	Std Dev	Prob	Obs.	Mean	Std Dev	Prob
Land	FSD: W_{99} over W_{90}	No	-8.98E+04	8.60E+04	p=0.00	No	-4.99	3.22	p=0.00
	FSD: W_{90} over W_{99}	No	-6.22E+05	4.14E+05	p=0.00	No	-0.57	1.82	p=0.00
	SSD: W_{99} over W_{90}	No	-2.43E+05	1.56E+05	p=0.01	No	-11.14	5.25	p=0.00
	SSD: W_{90} over W_{99}	No	-4.87E+05	4.41E+05	p=0.00	No	-0.24	0.88	p=0.00
	FSD: NW_{99} over NW_{90}	No	-6.76E+05	1.20E+06	p=0.02	No	-6.20	5.17	p=0.03
	FSD: NW_{90} over NW_{99}	No	-8.04E+06	5.34E+06	p=0.00	No	-901.35	1.43E+03	p=0.00
	SSD: NW_{99} over NW_{90}	No	-6.68E+05	7.98E+05	p=0.05	No	-12.85	13.01	p=0.08
	SSD: NW_{90} over NW_{99}	No	-1.13E+07	8.73E+05	p=0.00	No	-968.53	1.49E+03	p=0.01
Undergr.	FSD: W_{99} over W_{90}	Yes	-538.19	5.31E+03	p=0.98	Yes	-0.04	0.25	p=0.97
	FSD: W_{90} over W_{99}	No	-1.62E+05	1.83E+05	p=0.00	No	-1.62	1.82	p=0.00
	SSD: W_{99} over W_{90}	Yes	-533.41	5.30E+03	p=0.98	Yes	-0.04	0.25	p=0.97
	SSD: W_{90} over W_{99}	No	-1.62E+05	1.84E+05	p=0.00	No	-1.62	1.83	p=0.00
	FSD: NW_{99} over NW_{90}	Yes	-6.60E+05	2.17E+06	p=0.85	Yes	-0.19	0.66	p=0.83
	FSD: NW_{90} over NW_{99}	No	-5.73E+05	1.02E+06	p=0.00	No	-2.13	3.53	p=0.00
	SSD: NW_{99} over NW_{90}	Yes	-6.54E+05	2.15E+06	p=0.85	Yes	-0.19	0.66	p=0.85
	SSD: NW_{90} over NW_{99}	No	-6.33E+05	1.18E+06	p=0.00	No	-2.29	4.00	p=0.00

First-Stage Results

Table C1. First-Stage Regression Results.[!]

Dependent Variable	Ave. Wages		$(Ave.Wages)^2$		$(Ave.Wages)^3$	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Aggregate:						
Total	-4.56E+03	-40.74	475.87	41.88	-16.46	-42.85
Air	-4.49E+03	-40.51	468.57	41.64	-16.20	-42.59
Water	-2.45E+03	-28.95	251.05	29.27	-8.54	-29.46
Land	-2.16E+03	-25.00	222.23	25.32	-7.57	-25.53
Underground	-453.07	-10.42	46.05	10.44	-1.55	-10.42
Per Capita:						
Total	-2.36E+03	-36.73	247.43	37.94	-8.60	-39.00
Air	-2.28E+03	-36.43	238.65	37.63	-8.29	-38.68
Water	-763.02	-20.11	78.55	20.41	-2.68	-20.63
Land	-728.17	-18.69	75.41	19.09	-2.59	-19.40
Underground	-203.31	-9.02	20.67	9.04	-0.70	-9.03

[!] NOTES: Each regression also includes time fixed effects.



Panel A

Panel B

Panel D

Figure 1. Mean Total & Air Releases by Year & Race: County Level.

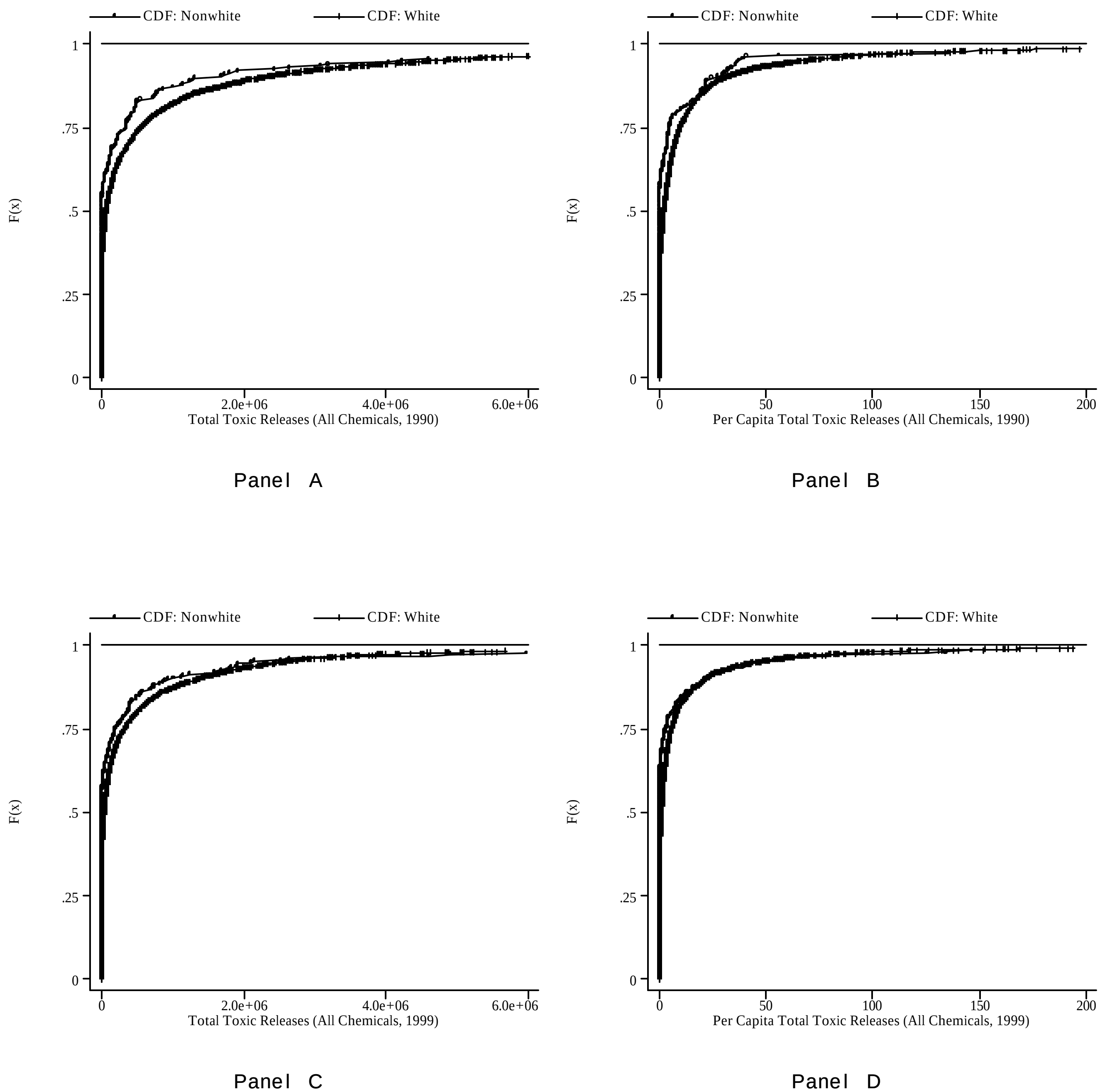
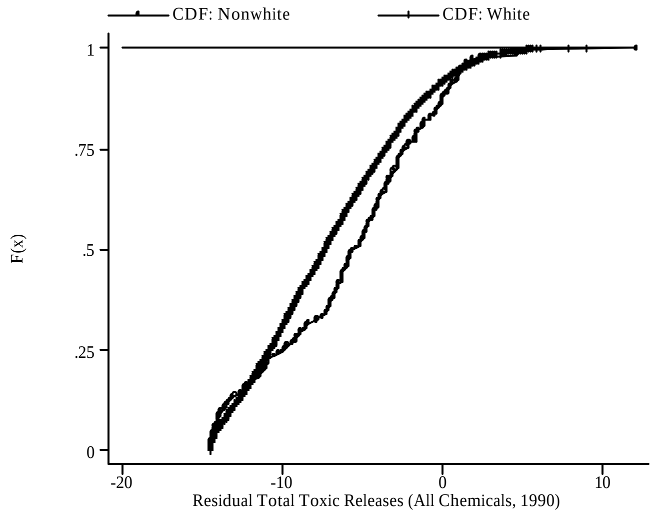
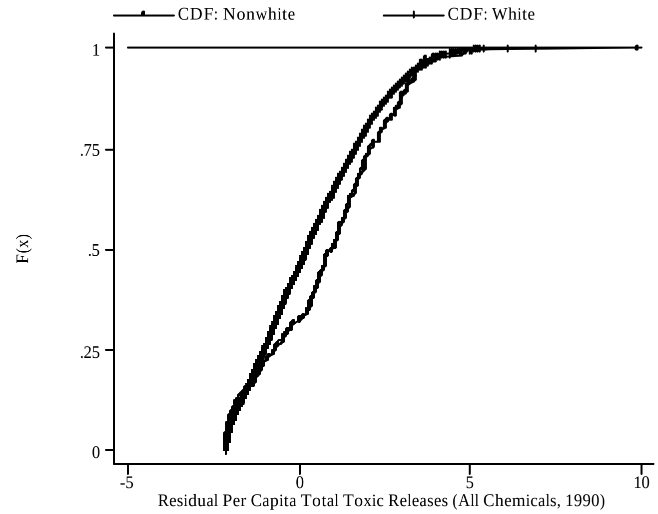


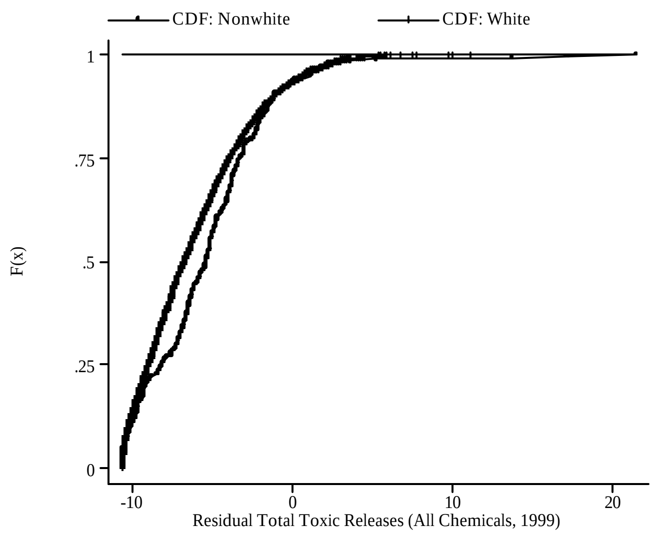
Figure 2. Cumulative Unconditional Density Functions:
Total Toxic Releases (Various Years).



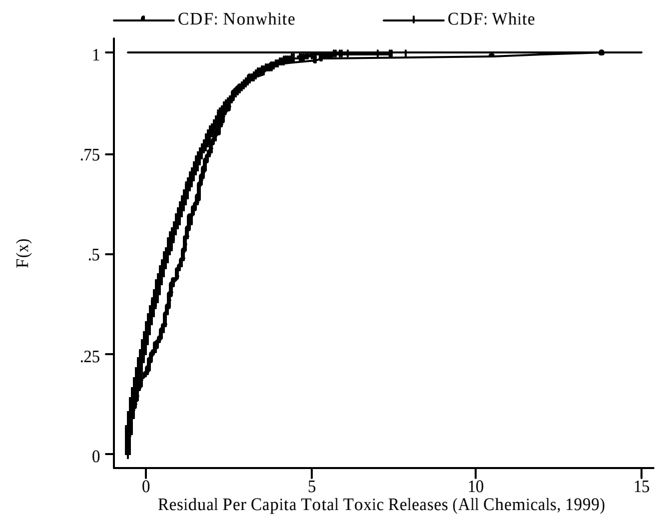
Panel A



Panel B



Panel C



Panel D

Figure 3. Cumulative Conditional Density Functions:
Total Toxic Releases (Various Years).

Table 1. Unconditional Stochastic Dominance Tests by Racial Composition: Total Toxic Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (All)	3141	1.19E+06	5.93E+06		3141	21.61	162.99	
1990 (White)	2954	1.17E+06	5.75E+06		2954	19.17	121.92	
1990 (Nonwhite)	187	1.45E+06	8.20E+06		187	60.14	459.26	
1999 (All)	3141	6.19E+05	2.64E+06		3141	12.32	76.75	
1999 (White)	2886	6.14E+05	2.59E+06		2886	11.44	52.78	
1999 (Nonwhite)	255	6.74E+05	3.21E+06		255	22.27	202.66	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-2.18E+06	2.82E+06	p=0.00	No	-54.85	46.24	p=0.00
FSD: NW_{90} over W_{90}	No	-2.68E+07	3.17E+07	p=0.07	No	-298.32	202.88	p=0.13
SSD: W_{90} over NW_{90}	No	-1.66E+07	1.02E+07	p=0.00	No	-254.72	119.84	p=0.00
SSD: NW_{90} over W_{90}	No	-3.55E+07	4.84E+07	p=0.36	No	-316.66	401.18	p=0.35
FSD: W_{99} over NW_{99}	No	-1.23E+06	1.39E+06	p=0.00	No	-19.76	28.85	p=0.00
FSD: NW_{99} over W_{99}	No	-7.62E+06	8.13E+06	p=0.09	No	-291.63	750.71	p=0.07
SSD: W_{99} over NW_{99}	No	-8.14E+06	5.38E+06	p=0.00	No	-108.84	85.71	p=0.00
SSD: NW_{99} over W_{99}	No	-9.49E+06	1.43E+07	p=0.44	No	-381.42	858.27	p=0.30
FSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	-0.04	0.85	p=1.00
FSD: W_{90} over W_{99}	No	-7.89E+06	3.34E+06	p=0.00	No	-96.85	35.56	p=0.00
SSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	0.00	0.00	p=1.00
SSD: W_{90} over W_{99}	No	-2.84E+07	2.15E+07	p=0.00	No	-445.14	67.56	p=0.00
FSD: NW_{99} over NW_{90}	Yes	-1.27E+06	4.32E+06	p=0.27	No	-29.26	29.94	p=0.03
FSD: NW_{90} over NW_{99}	No	-3.15E+07	3.26E+07	p=0.00	No	-2.31E+03	1.90E+03	p=0.00
SSD: NW_{99} over NW_{90}	Yes	-8.35E+05	3.83E+06	p=0.59	Yes	-21.98	55.11	p=0.65
SSD: NW_{90} over NW_{99}	No	-6.22E+07	4.79E+07	p=0.00	No	-3.19E+03	2.80E+03	p=0.00

[!]NOTES: Results based on all reported TRI chemicals for each year.

Table 2. Conditional Stochastic Dominance Tests by Racial Composition: Total Toxic Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (White)	2921	-8.42	3.59		2921	0.38	1.71	
1990 (Nonwhite)	183	-7.51	3.90		183	0.87	1.90	
1999 (White)	2857	-7.70	2.73		2857	0.93	1.27	
1999 (Nonwhite)	251	-6.99	3.15		251	1.32	1.69	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-0.91	0.51	p=0.01	No	-0.30	0.20	p=0.01
FSD: NW_{90} over W_{90}	No	-3.95	2.47	p=0.00	No	-1.98	1.87	p=0.00
SSD: W_{90} over NW_{90}	No	-5.39	5.58	p=0.08	No	-1.16	1.49	p=0.08
SSD: NW_{90} over W_{90}	No	-119.72	38.81	p=0.00	No	-46.98	13.96	p=0.00
FSD: W_{99} over NW_{99}	No	-0.49	0.48	p=0.06	No	-0.17	0.20	p=0.23
FSD: NW_{99} over W_{99}	No	-8.08	5.88	p=0.00	No	-4.38	3.12	p=0.00
SSD: W_{99} over NW_{99}	No	-0.14	0.39	p=0.34	Yes	0.01	0.03	p=0.79
SSD: NW_{99} over W_{99}	No	-89.52	26.51	p=0.00	No	-36.44	10.25	p=0.00
FSD: W_{99} over W_{90}	No	-3.86	0.01	p=0.00	No	-1.59	1.95E-03	p=0.00
FSD: W_{90} over W_{99}	No	-0.80	0.13	p=0.00	No	-0.15	0.05	p=0.00
SSD: W_{99} over W_{90}	No	-102.02	3.33	p=0.00	No	-54.38	1.55	p=0.00
SSD: W_{90} over W_{99}	Yes	3.86	0.01	p=1.00	Yes	1.59	1.95E-03	p=1.00
FSD: NW_{99} over NW_{90}	No	-7.08	3.98	p=0.00	No	-3.65	2.46	p=0.00
FSD: NW_{90} over NW_{99}	No	-2.23	0.99	p=0.00	No	-0.74	0.68	p=0.00
SSD: NW_{99} over NW_{90}	No	-92.01	17.77	p=0.00	No	-47.05	8.83	p=0.00
SSD: NW_{90} over NW_{99}	Yes	3.36	3.00	p=0.97	Yes	1.60	0.01	p=1.00

[!]NOTES: Results based on all reported TRI chemicals for each year.

Table 3. Unconditional Stochastic Dominance Tests by Racial Composition: Toxic Air Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (All)	3141	7.43E+05	2.94E+06		3141	12.75	76.09	
1990 (White)	2954	7.48E+05	2.94E+06		2954	12.64	76.36	
1990 (Nonwhite)	187	6.64E+05	2.93E+06		187	14.43	71.86	
1999 (All)	3141	3.72E+05	1.36E+06		3141	7.24	33.50	
1999 (White)	2886	3.69E+05	1.31E+06		2886	7.15	33.70	
1999 (Nonwhite)	255	4.09E+05	1.79E+06		255	8.31	31.16	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-2.03E+06	1.13E+06	p=0.00	No	-41.91	25.49	p=0.00
FSD: NW_{90} over W_{90}	No	-8.56E+06	8.98E+06	p=0.18	No	-298.33	202.88	p=0.13
SSD: W_{90} over NW_{90}	No	-1.86E+07	7.67E+06	p=0.00	No	-254.72	119.84	p=0.00
SSD: NW_{90} over W_{90}	Yes	-5.48E+06	1.10E+07	p=0.67	No	-316.66	401.18	p=0.35
FSD: W_{99} over NW_{99}	No	-5.22E+05	5.27E+05	p=0.00	No	-5.99	7.75	p=0.00
FSD: NW_{99} over W_{99}	No	-3.32E+06	5.45E+06	p=0.10	No	-100.33	67.66	p=0.03
SSD: W_{99} over NW_{99}	No	-4.47E+06	3.25E+06	p=0.00	No	-65.08	40.59	p=0.00
SSD: NW_{99} over W_{99}	Yes	-4.02E+06	7.17E+06	p=0.50	No	-170.90	166.26	p=0.23
FSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	0.00	0.00	p=1.00
FSD: W_{90} over W_{99}	No	-4.16E+06	7.79E+05	p=0.00	No	-60.13	15.19	p=0.00
SSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	0.00	0.00	p=1.00
SSD: W_{90} over W_{99}	No	-2.84E+07	2.15E+06	p=0.00	No	-381.29	38.28	p=0.00
FSD: NW_{99} over NW_{90}	No	-1.11E+06	3.30E+06	p=0.20	No	-26.57	26.37	p=0.05
FSD: NW_{90} over NW_{99}	No	-1.17E+07	8.96E+06	p=0.00	No	-296.88	173.77	p=0.00
SSD: NW_{99} over NW_{90}	Yes	-7.87E+05	2.96E+06	p=0.62	Yes	-19.97	48.03	p=0.64
SSD: NW_{90} over NW_{99}	No	-2.50E+07	1.63E+07	p=0.00	No	-532.24	394.71	p=0.00

[!]NOTES: Results based on all reported TRI chemicals for each year.

Table 4. Conditional Stochastic Dominance Tests by Racial Composition: Toxic Air Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (White)	2921	-8.26	3.54		2921	0.51	1.65	
1990 (Nonwhite)	183	-7.37	3.85		183	0.98	1.84	
1999 (White)	2857	-7.44	2.69		2857	1.13	1.22	
1999 (Nonwhite)	251	-6.75	3.10		251	1.51	1.63	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-0.88	0.51	p=0.01	No	-0.28	0.21	p=0.01
FSD: NW_{90} over W_{90}	No	-3.86	2.36	p=0.00	No	-1.91	1.81	p=0.00
SSD: W_{90} over NW_{90}	No	-5.09	5.31	p=0.12	No	-0.97	1.22	p=0.08
SSD: NW_{90} over W_{90}	No	-120.91	37.88	p=0.00	No	46.03	13.54	p=0.00
FSD: W_{99} over NW_{99}	No	-0.48	0.47	p=0.08	No	-0.16	0.19	p=0.22
FSD: NW_{99} over W_{99}	No	-8.12	5.72	p=0.00	No	-4.34	2.97	p=0.00
SSD: W_{99} over NW_{99}	No	-0.14	0.46	p=0.37	No	0.01	0.02	p=0.79
SSD: NW_{99} over W_{99}	No	-89.31	25.00	p=0.00	No	-34.98	9.91	p=0.00
FSD: W_{99} over W_{90}	No	-3.96	0.01	p=0.00	No	-1.63	1.86E-03	p=0.00
FSD: W_{90} over W_{99}	No	-0.65	0.13	p=0.00	No	-0.06	0.05	p=0.13
SSD: W_{99} over W_{90}	No	-109.77	3.54	p=0.00	No	-60.80	1.65	p=0.00
SSD: W_{90} over W_{99}	Yes	3.96	0.01	p=1.00	Yes	1.63	1.86E-03	p=1.00
FSD: NW_{99} over NW_{90}	No	-6.79	3.65	p=0.00	No	-3.72	2.42	p=0.00
FSD: NW_{90} over NW_{99}	No	-2.21	1.23	p=0.00	No	-0.64	0.68	p=0.00
SSD: NW_{99} over NW_{90}	No	-97.12	18.61	p=0.00	No	-52.11	8.54	p=0.00
SSD: NW_{90} over NW_{99}	Yes	3.85	1.21	p=0.99	Yes	1.64	0.01	p=1.00

[!]NOTES: Results based on all reported TRI chemicals for each year.

Table 5. Unconditional Stochastic Dominance Tests by Racial Composition: Toxic Water Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (All)	3141	6.40E+04	1.45E+06		3141	1.93	66.82	
1990 (White)	2954	4.09E+04	4.44E+05		2954	0.78	9.32	
1990 (Nonwhite)	187	4.29E+05	5.66E+06		187	20.12	271.39	
1999 (All)	3141	8.07E+04	8.34E+05		3141	1.52	12.35	
1999 (White)	2886	8.12E+04	8.58E+05		2886	1.58	12.82	
1999 (Nonwhite)	255	7.52E+04	4.81E+05		255	0.88	4.29	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-2.10E+05	2.21E+05	p=0.01	No	-3.83	-3.22	p=0.00
FSD: NW_{90} over W_{90}	No	-1.85E+07	3.26E+07	p=0.15	No	-891.46	1.57E+03	p=0.17
SSD: W_{90} over NW_{90}	No	-3.34E+05	3.79E+05	p=0.02	No	-7.89	6.88	p=0.00
SSD: NW_{90} over W_{90}	No	-1.96E+07	3.56E+07	p=0.32	No	-963.17	1.78E+03	p=0.29
FSD: W_{99} over NW_{99}	No	-3.34E+05	3.05E+05	p=0.00	No	-12.24	9.91	p=0.00
FSD: NW_{99} over W_{99}	No	-1.16E+06	1.16E+06	p=0.14	No	-4.26	9.18	p=0.14
SSD: W_{99} over NW_{99}	No	-9.99E+05	8.41E+05	p=0.00	No	-16.51	16.69	p=0.00
SSD: NW_{99} over W_{99}	No	-1.51E+06	2.14E+06	p=0.40	No	-10.26	15.18	p=0.41
FSD: W_{99} over W_{90}	No	-8.54E+05	3.43E+05	p=0.00	No	-23.92	6.67	p=0.00
FSD: W_{90} over W_{99}	No	-980.28	1.43E+04	p=0.14	No	-4.68E-03	3.91E-03	p=0.06
SSD: W_{99} over W_{90}	No	-2.40E+06	5.49E+05	p=0.00	No	-50.89	10.45	p=0.00
SSD: W_{90} over W_{99}	No	-526.12	777.60	p=0.30	No	-0.02	0.02	p=0.19
FSD: NW_{99} over NW_{90}	No	-1.67E+06	1.28E+06	p=0.00	No	-12.72	8.84	p=0.00
FSD: NW_{90} over NW_{99}	No	-1.98E+07	3.29E+07	p=0.01	No	-845.56	1.55E+03	p=0.01
SSD: NW_{99} over NW_{90}	No	-2.96E+06	2.43E+06	p=0.02	No	-39.40	20.60	p=0.00
SSD: NW_{90} over NW_{99}	No	-2.10E+07	3.65E+07	p=0.02	No	-891.32	1.69E+03	p=0.01

[!]NOTES: Results based on all reported TRI chemicals for each year.

Table 6. Conditional Stochastic Dominance Tests by Racial Composition: Toxic Water Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (White)	2921	-2.64	1.97		2921	3.85	0.55	
1990 (Nonwhite)	183	-2.25	2.17		183	3.98	0.60	
1999 (White)	2857	-2.76	1.67		2857	3.72	0.45	
1999 (Nonwhite)	251	-2.46	1.71		251	3.82	0.48	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-0.96	0.34	p=0.00	No	-0.15	0.06	p=0.00
FSD: NW_{90} over W_{90}	No	-1.61	0.31	p=0.01	No	-0.29	0.05	p=0.01
SSD: W_{90} over NW_{90}	No	-10.08	7.01	p=0.00	No	-1.36	0.98	p=0.00
SSD: NW_{90} over W_{90}	No	-62.24	24.66	p=0.01	No	-12.19	4.44	p=0.01
FSD: W_{99} over NW_{99}	No	-0.53	0.26	p=0.00	No	-0.07	0.05	p=0.01
FSD: NW_{99} over W_{99}	No	-1.19	0.22	p=0.00	No	-0.43	0.26	p=0.00
SSD: W_{99} over NW_{99}	No	-3.17	2.70	p=0.01	No	-0.25	0.29	p=0.09
SSD: NW_{99} over W_{99}	No	-47.47	15.81	p=0.00	No	-9.48	3.10	p=0.00
FSD: W_{99} over W_{90}	No	-1.75	0.04	p=0.00	No	-0.22	-3.72E-03	p=0.00
FSD: W_{90} over W_{99}	No	-0.76	0.05	p=0.00	No	-0.27	0.01	p=0.00
SSD: W_{99} over W_{90}	No	-17.39	1.30	p=0.00	No	-1.35	0.12	p=0.00
SSD: W_{90} over W_{99}	No	-12.21	2.61	p=0.00	No	-13.51	0.49	p=0.00
FSD: NW_{99} over NW_{90}	No	-1.89	0.09	p=0.00	No	-0.32	0.18	p=0.00
FSD: NW_{90} over NW_{99}	No	-1.36	0.21	p=0.00	No	-0.40	0.04	p=0.00
SSD: NW_{99} over NW_{90}	No	-25.10	8.62	p=0.00	No	-2.52	0.87	p=0.00
SSD: NW_{90} over NW_{99}	No	-28.27	16.60	p=0.00	No	-16.69	3.19	p=0.00

[!] NOTES: Results based on all reported TRI chemicals for each year.

Table 7. Unconditional Stochastic Dominance Tests by Racial Composition: Toxic Land Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (All)	3141	1.40E+05	1.55E+06		3141	3.61	74.91	
1990 (White)	2954	1.33E+05	1.53E+06		2954	2.37	32.60	
1990 (Nonwhite)	187	2.56E+05	1.94E+06		187	23.14	278.31	
1999 (All)	3141	1.03E+05	1.40E+06		3141	2.86	63.80	
1999 (White)	2886	9.85E+04	1.40E+06		2886	1.96	30.86	
1999 (Nonwhite)	255	1.54E+05	1.45E+06		255	13.07	198.45	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-3.10E+05	5.65E+05	p=0.00	No	-4.05	6.74	p=0.00
FSD: NW_{90} over W_{90}	No	-8.92E+06	7.01E+06	p=0.08	No	-964.49	1.50E+03	p=0.07
SSD: W_{90} over NW_{90}	No	-5.71E+05	8.90E+05	p=0.01	No	-7.66	9.50	p=0.00
SSD: NW_{90} over W_{90}	No	-1.40E+07	1.31E+07	p=0.14	No	-1.14E+03	1.86E+03	p=0.12
FSD: W_{99} over NW_{99}	No	-2.28E+05	3.50E+05	p=0.04	No	-3.44	4.98	p=0.01
FSD: NW_{99} over W_{99}	No	-4.30E+06	6.27E+06	p=0.03	No	-269.97	866.34	p=0.07
SSD: W_{99} over NW_{99}	No	-1.99E+05	4.12E+05	p=0.07	No	-4.83	7.73	p=0.03
SSD: NW_{99} over W_{99}	No	-5.43E+06	7.64E+06	p=0.10	No	-287.70	903.61	p=0.17
FSD: W_{99} over W_{90}	No	-2.15E+04	1.84E+04	p=0.02	No	-1.45	1.71	p=0.02
FSD: W_{90} over W_{99}	No	-1.34E+06	5.78E+06	p=0.00	No	-10.50	9.05	p=0.00
SSD: W_{99} over W_{90}	No	-6.53E+04	6.67E+04	p=0.15	No	-3.26	3.13	p=0.10
SSD: W_{90} over W_{99}	No	-1.72E+06	7.63E+05	p=0.00	No	-10.39	10.34	p=0.00
FSD: NW_{99} over NW_{90}	No	-6.56E+05	1.25E+06	p=0.00	No	-4.51	4.02	p=0.01
FSD: NW_{90} over NW_{99}	No	-8.35E+06	5.40E+06	p=0.00	No	-936.32	1.43E+03	p=0.00
SSD: NW_{99} over NW_{90}	No	-7.79E+05	8.63E+05	p=0.02	No	-11.11	10.54	p=0.03
SSD: NW_{90} over NW_{99}	No	-1.18E+07	8.86E+06	p=0.01	No	-1.03E+03	1.51E+03	p=0.02

[!]NOTES: Results based on all reported TRI chemicals for each year.

Table 8. Conditional Stochastic Dominance Tests by Racial Composition: Toxic Land Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (White)	2921	-2.56	1.76		2921	3.83	0.51	
1990 (Nonwhite)	183	-2.21	1.94		183	3.96	0.56	
1999 (White)	2857	-2.22	1.48		2857	3.87	0.40	
1999 (Nonwhite)	251	-1.96	1.51		251	3.98	0.46	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-0.85	0.29	p=0.00	No	-0.11	0.05	p=0.01
FSD: NW_{90} over W_{90}	No	-1.40	0.27	p=0.00	No	-0.08	0.02	p=0.00
SSD: W_{90} over NW_{90}	No	-8.97	6.02	p=0.01	No	-0.66	0.43	p=0.05
SSD: NW_{90} over W_{90}	No	-53.94	21.73	p=0.01	No	-2.73	1.27	p=0.00
FSD: W_{99} over NW_{99}	No	-0.44	0.22	p=0.00	No	-0.05	0.05	p=0.04
FSD: NW_{99} over W_{99}	No	2.69	2.35	p=0.00	No	-0.81	0.55	p=0.00
SSD: W_{99} over NW_{99}	No	-1.07	0.25	p=0.01	No	-0.06	0.13	p=0.16
SSD: NW_{99} over W_{99}	No	-41.65	14.21	p=0.00	No	-9.99	2.89	p=0.00
FSD: W_{99} over W_{90}	No	-2.26	0.04	p=0.00	No	-0.37	9.68E-04	p=0.00
FSD: W_{90} over W_{99}	No	0.04	0.05	p=0.79	No	-0.11	0.01	p=0.00
SSD: W_{99} over W_{90}	No	-60.57	2.23	p=0.00	No	-7.23	0.30	p=0.00
SSD: W_{90} over W_{99}	Yes	2.26	0.04	p=1.00	Yes	0.37	9.68E-04	p=1.00
FSD: NW_{99} over NW_{90}	No	-2.38	0.10	p=0.00	No	-0.65	0.36	p=0.00
FSD: NW_{90} over NW_{99}	No	-0.50	0.19	p=0.00	No	-0.26	0.09	p=0.00
SSD: NW_{99} over NW_{90}	No	-51.79	12.28	p=0.00	No	-7.34	1.62	p=0.00
SSD: NW_{90} over NW_{99}	Yes	2.35	0.15	p=1.00	Yes	-0.83	1.74	p=0.55

[!]NOTES: Results based on all reported TRI chemicals for each year.

Table 9. Unconditional Stochastic Dominance Tests by Racial Composition: Toxic Underground Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	N	Mean	Std Dev		N	Mean	Std Dev	
1990 (All)	3141	2.41E+05	3.78E+06		3141	3.32	67.60	
1990 (White)	2954	2.50E+05	3.90E+06		2954	3.37	69.28	
1990 (Nonwhite)	187	1.00E+05	8.53E+05		187	2.45	30.74	
1999 (All)	3141	6.35E+04	9.84E+05		3141	0.70	14.60	
1999 (White)	2886	6.59E+04	1.01E+06		2886	0.76	15.23	
1999 (Nonwhite)	255	3.62E+04	5.75E+05		255	0.01	0.18	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	Yes	-1.19E+06	1.80E+06	p=0.42	No	-17.59	18.63	p=0.06
FSD: NW_{90} over W_{90}	No	-2.80E+06	2.79E+06	p=0.07	No	-92.49	161.24	p=0.15
SSD: W_{90} over NW_{90}	Yes	-1.17E+06	1.85E+06	p=0.46	No	-16.82	19.26	p=0.13
SSD: NW_{90} over W_{90}	No	-4.09E+06	4.80E+06	p=0.08	No	-102.48	184.71	p=0.16
FSD: W_{99} over NW_{99}	No	-1.30E+05	2.12E+05	p=0.20	No	-1.71	2.03	p=0.08
FSD: NW_{99} over W_{99}	Yes	-7.47E+05	2.49E+05	p=0.65	Yes	-0.11	-0.50	p=0.72
SSD: W_{99} over NW_{99}	No	-1.29E+05	2.12E+05	p=0.21	No	-1.70	2.04	p=0.09
SSD: NW_{99} over W_{99}	Yes	-7.75E+05	2.62E+06	p=0.65	Yes	-0.12	-0.50	p=0.72
FSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	0.00	0.00	p=1.00
FSD: W_{90} over W_{99}	No	-3.65E+06	1.51E+06	p=0.00	No	-34.66	16.78	p=0.00
SSD: W_{99} over W_{90}	Yes	0.00	0.00	p=1.00	Yes	0.00	0.00	p=1.00
SSD: W_{90} over W_{99}	No	-3.70E+06	1.56E+06	p=0.00	No	-35.33	17.61	p=0.00
FSD: NW_{99} over NW_{90}	Yes	-2.35E+05	1.23E+06	p=0.91	Yes	-0.04	0.33	p=0.95
FSD: NW_{90} over NW_{99}	No	-5.14E+06	3.45E+06	p=0.00	No	-124.23	179.06	p=0.00
SSD: NW_{99} over NW_{90}	Yes	-2.24E+05	1.36E+06	p=0.93	Yes	-0.04	0.33	p=0.95
SSD: NW_{90} over NW_{99}	No	-7.07E+06	5.94E+06	p=0.00	No	-140.73	210.81	p=0.00

[!]NOTES: Results based on all reported TRI chemicals for each year.

Table 10. Conditional Stochastic Dominance Tests by Racial Composition: Toxic Underground Releases.[!]

	Aggregate				Per Capita			
Summary Statistics	**N**	**Mean**	**Std Dev**		**N**	**Mean**	**Std Dev**	
1990 (White)	2921	-0.47	0.35		2921	4.44	0.15	
1990 (Nonwhite)	183	-0.41	0.39		183	4.47	0.17	
1999 (White)	2857	-0.21	0.31		2857	4.52	0.14	
1999 (Nonwhite)	251	-0.16	0.32		251	4.54	0.14	
Tests	Observed	Mean	Std Dev	Prob	Observed	Mean	Std Dev	Prob
FSD: W_{90} over NW_{90}	No	-0.20	0.07	p=0.00	No	-0.06	0.02	p=0.00
FSD: NW_{90} over W_{90}	No	-0.25	0.05	p=0.00	No	-0.08	0.02	p=0.00
SSD: W_{90} over NW_{90}	No	-2.27	1.35	p=0.00	No	-0.66	0.43	p=0.01
SSD: NW_{90} over W_{90}	No	-8.61	4.19	p=0.02	No	-2.73	1.27	p=0.02
FSD: W_{99} over NW_{99}	No	-0.13	0.04	p=0.00	No	-0.04	0.01	p=0.00
FSD: NW_{99} over W_{99}	No	-0.20	0.04	p=0.00	No	-0.06	0.01	p=0.00
SSD: W_{99} over NW_{99}	No	-1.05	0.73	p=0.02	No	-0.29	0.20	p=0.01
SSD: NW_{99} over W_{99}	No	-7.07	2.88	p=0.00	No	-2.20	0.85	p=0.00
FSD: W_{99} over W_{90}	No	-0.80	0.02	p=0.00	No	-0.16	4.84E-03	p=0.00
FSD: W_{90} over W_{99}	Yes	0.48	0.01	p=1.00	Yes	0.05	2.32E-03	p=1.00
SSD: W_{99} over W_{90}	No	-54.19	0.41	p=0.00	No	-7.46	0.12	p=0.00
SSD: W_{90} over W_{99}	Yes	0.80	0.02	p=1.00	Yes	0.16	4.84E-03	p=1.00
FSD: NW_{99} over NW_{90}	No	-0.88	0.03	p=0.00	No	-0.18	0.01	p=0.00
FSD: NW_{90} over NW_{99}	Yes	0.39	0.03	p=1.00	Yes	0.03	0.01	p=0.99
SSD: NW_{99} over NW_{90}	No	-52.19	2.66	p=0.00	No	-6.82	0.84	p=0.00
SSD: NW_{90} over NW_{99}	Yes	0.88	0.03	p=1.00	Yes	0.18	0.01	p=1.00

[!] NOTES: Results based on all reported TRI chemicals for each year.