Socioeconomic Disadvantage and Environmentally Hazardous Facility Location in Pennsylvania

Jeremy Mennis

Department of Geography, UCB 260
University of Colorado
Boulder, CO 80309
Phone: (303) 492-4794
Fax: (303) 492-7501
Email: jeremy@colorado.edu

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Abstract

This study explores the spatial relationship between socioeconomic disadvantage and the distribution of environmentally hazardous facilities listed in the U.S. Environmental Protection Agency's Toxic Release Inventory (TRI) database in Pennsylvania. Measurements of distance to, and density of, TRI facilities were predicted using U.S. Census tract level variables indicating race, poverty, educational attainment, and manufacturing employment in analyses of the entire state and of the southeast Pennsylvania Philadelphia metropolitan area. Results indicate that at the state-wide level percent minority increases with proximity to, and density of, TRI facilities. In southeast Pennsylvania high percent minority and poverty, and low educational attainment, are associated with concentrations of TRI facilities. Manufacturing employment was not found to be significantly related to TRI facility location. This study suggests that urban versus rural land use and demographic patterns are key components in understanding socioeconomic inequity in the distribution of TRI facilities in Pennsylvania.

Introduction

The issue of environmental justice has emerged as a primary influence on environmental policy at both the state and federal levels in the U.S. Environmental justice activists argue that racial minorities and the poor are subject to an inequitable exposure to environmental risk. This argument has been utilized with mixed success in litigation aimed at stopping the development of locally unwanted land uses in minority and low-income communities (cf. Hill 2002). The issue of environmental justice has consequently caught the attention of the U.S. Environmental Protection Agency (EPA), which has established the Office of Environmental Justice explicitly to deal with issues of socioeconomic inequity in both exposure to environmental risk and access to the environmental decision-making process. Investigating the complex relationships between socioeconomic character and environmental risk thus contributes to the formation of environmental policy, as well as to a greater theoretical understanding of patterns of demography and industrial development.

The purpose of this study is to explore the spatial relationship between the distribution of environmentally hazardous facilities and socioeconomic disadvantage in Pennsylvania. For hazardous facility data, I focus on the locations of facilities listed in the EPA's Toxic Release Inventory (TRI) System database. Development of the TRI database was mandated by the Emergency Planning and Community Right-to-Know Act (EPCRA) and requires facilities to report on the amounts of certain toxic chemicals that they release into the environment. While the use of TRI data for environmental justice analysis is not without its drawbacks, such as questions about data accuracy (Scott et al. 1997), the TRI database provides the means to gauge the spatial distribution of a set of hazardous facilities defined directly by environmental regulation. In addition, the database is easily acquired via download from the Internet. For these reasons, the TRI database has been used in many environmental justice analyses at the national and regional scales (e.g. Burke 1993, Daniels and Friedman 1999, Mitchell et al. 1999).

Other environmental justice studies focusing on Pennsylvania have shown evidence of socioeconomic inequity in the distribution of TRI facilities. In an analysis of Allegheny County, Pennsylvania, including Pittsburgh, Glickman et al. (1995) explored how changing the areal unit of analysis that defines the 'neighborhood' that hosts the TRI facility (e.g. U.S. Census block group versus tract) influences the analysis of environmental justice. These authors found that while the evidence of inequity varied according to the different definitions of neighborhood that were used, statistical evidence indicated that there is clearly a spatial coincidence between concentrations of TRI facilities, black population, and those living in poverty in Allegheny County. Mennis (2002) used a dasymetric mapping approach to reallocate census data to sub-block group resolution in order to summarize these data by zones of uniform distance to, and density of, TRI facilities in southeast Pennsylvania, including Philadelphia. Results demonstrated that socioeconomic disadvantage increased with proximity to, and density of, TRI facilities.

Both of these studies indicate environmental injustice, as indicated by hazardous facility location, in Pennsylvania's two largest urban areas. This is perhaps not surprising given that both these cities host most of the state's minority population and are centers of industry. In the present study, I extend this research to incorporate all of Pennsylvania, thus including many predominantly white, rural areas that host TRI facilities. I then compare measures of inequity in TRI distribution derived from an analysis of the state as a whole to those derived from an analysis limited to the urbanized southeast Pennsylvania region, including Philadelphia, Montgomery, Bucks, Chester, and Delaware counties (figure 1).

Data and Methods

U.S. Census tract level data were used to capture socioeconomic character. Because census 2000 data are not yet fully available for Pennsylvania, 1990 census data were used for this research. In 1990 there were 3,167 tracts in Pennsylvania. However, I used only 3,055 of these tracts in this analysis by removing those with missing data or with less than 100 persons, as the calculation of percent variables for a tract with so few persons can easily skew the data. Only 97 tracts were removed for having less than 100 persons, and 62 of those had zero population. Of these 3,055 tracts, 948 resided in southeast Pennsylvania. Pennsylvania TRI facility data for 1987-1990 were acquired from the Pennsylvania Spatial Data Access web site (www.pasda.psue.edu). This data set contains 336 TRI facilities for southeast Pennsylvania and 1508 for the entire state (figure 1).

The following census variables were used to capture indicators of socioeconomic status regarding race, poverty, and educational attainment: percent minority (including Hispanics of any race), percent of persons living below the poverty line (hereafter, percent poverty), and percent of persons over 25 with a bachelors or more advanced degree (hereafter, percent degree). I also calculated the percent of persons over 16 working in the manufacturing industry (hereafter, percent manufacturing) because this variable may indicate a benefit, as opposed to negative consequence, of living close to a hazardous facility and has been shown to be positively correlated with the locations of hazardous facilities in previous studies (Anderton et al. 1994, Daniels and Friedman 1999). As a measure of urbanization, population density for each tract was also calculated.

ArcInfo GIS (Environmental Systems Research Institute, Inc.) was used to calculate measures of the distance to nearest TRI facility in meters (hereafter, distance) and density of TRI facilities in units of facilities per km^2 (hereafter, density). Distance was calculated by generating a 100 meter raster grid of distance to nearest TRI facility and finding the mean grid cell value for each tract. Density was calculated by generating a 100 meter raster grid where each grid cell was assigned a value based on the number of TRI facilities within 5 km of that grid cell. The use of a 5 km radius is somewhat arbitrary but captures the immediate area surrounding a location, and similar radii of hazardous facility influence have been used in previous studies (Anderton et al. 1994). The mean density value was then summarized for each tract. OLS regression was used to predict tract distance to, and density of, TRI facilities based on the socioeconomic data. These analyses were performed for both southeast Pennsylvania and for the entire state.

Results

Tables 1 and 2 show the results of the regressions of distance and density, respectively, for the entire state of Pennsylvania. Note that distance and density have been transformed by taking the natural log and square root, respectively, to better approach a normal distribution of the dependent variable. The low R^2 values for the models of both regressions indicate the general weakness of the models, although R^2 values such as these are not uncommon in environmental justice analyses utilizing regression with such a large number of observations (e.g. Daniels and Friedman 1999). Of particular importance is that of the five independent variables, percent minority explains the greatest amount of variation in both distance and density. As percent minority increases, distance decreases and density increases. The other independent variables add only marginal amounts of explanatory power, although higher percent poverty and educational attainment are also associated with proximity to, and higher density of, TRI facilities. Percent manufacturing and population density were found to be not significant.

The results of the distance and density regressions for southeast Pennsylvania are shown in tables 3 and 4, respectively. Note that the R^2 values are uniformly higher than those of the Pennsylvania regression models, indicating that more of the variation in distance and density is explained by socioeconomic character (as captured by these variables) in southeast Pennsylvania than for the state as a whole. Model 1 in both tables 3 and 4 show that percent minority is a also significant predictor of distance and density in southeast Pennsylvania. As percent minority increases, distance decreases and density increases, although model 2 in tables 3 and 4 shows that much of the influence of percent minority can be explained by variation in percent poverty. Percent minority and percent poverty are, in fact, highly positively correlated in southeast Pennsylvania ($r = 0.77$). Interestingly, when percent degree and population density are added into the regression equation, such as in model 5 in table 4, the influence of percent minority actually increases, but as an influence of the opposite sign as compared to model 1. In other words, when the influence of poverty, degree, and population density are controlled for, concentrations of TRI facilities are associated with lower percent minority. Percent manufacturing was again found to be not significant.

Discussion

The results of the state-wide regressions indicate that race is clearly a significant factor in predicting the distance to, and density of, TRI facilities in Pennsylvania. While the relationship is relatively weak, it is perhaps surprising that it is evident at all considering the great degree of socioeconomic variation in tracts across the entire state. No other variable indicating poverty, educational attainment, or manufacturing employment offers the explanatory value that race holds. This is particularly noteworthy in light of the prominent environmental justice debate over which is a better predictor of hazardous facility location: race, class, or employment (e.g. Anderton et al. 1994, Downey 1999). While I do not subscribe to the viewpoint that this question should be the focal point of environmental justice research, or that the strength of one factor necessarily indicates the weakness of the others, the present study clearly demonstrates that race is the superior predictor of TRI facility location in a state-wide analysis of Pennsylvania, trumping indicators of class and employment that have been found to be of greater significance than race in other studies (e.g. Anderton et al. 1994, Bowen et al. 1995).

The non-linearity of the relationship between percent minority and distance to, and density of, TRI facilities is also important. The log and square root transforms of distance and density indicate that while percent minority is generally relatively high where TRI facilities are concentrated, percent minority declines rapidly and plateuas as distance and density increase. This makes sense logically as well; one would expect that there is some radius of influence that a TRI facility has on its surroundings, and that this influence would be felt most strongly at closer proximities.

Another interpretation of this relationship stems from the concentration of some clusters of TRI facilities in Pennsylvania's urban areas (figure 1), which are also home to most of the state's minority population. Because tracts in urban areas are typically much smaller than those in rural areas, the number of urban as compared to rural tracts entered into the regression is disproportionately high for the area of the state they occupy. The small size and urban location of most high percent minority tracts results in low distance and high density measurements. Whereas many low percent minority tracts are also located close to TRI facilities, many are not because tracts with low percent minority are distributed relatively homogeneously throughout the state.

The analysis of southeast Pennsylvania sheds light on the socioeconomic patterns associated specifically with TRI facility location within a greater urban area. First, note that the R^2 values are higher than those derived for the state-wide analysis, indicating a better explanation of the variation in distance and density. While minority is still significantly related to distance and density, as it is in the state-wide analysis, its variation may be explained by percent poverty. One could thus argue that class is more important that race in explaining TRI facility location, although it could also be said that minorities tend to live closer to concentrations of TRI facilities, and they tend to be poor. Tracts that are located in denser areas of TRI facilities also tend to have higher population density (i.e. are located in the urban core) and have lower educational attainment. The fact that percent minority 'flips' sign when percent poverty is introduced suggests that in cases where a tract has a high percent minority and low percent poverty, the tract is likely to be located relatively far from concentrations of TRI facilities. Although the high correlation between the two variables indicates that the combination of high percent minority and low percent poverty within a single tract is unusual.

Overall, this study shows evidence of socioeconomic inequity in the distribution of TRI facilities in Pennsylvania. When all tracts in the state are considered, tracts with high percent minority are significantly more likely to be located closer to, and in areas of higher density of, TRI facilities. This racial disparity is independent of poverty, educational attainment, and manufacturing employment. When the largest metropolitan area in Pennsylvania is considered in isolation, evidence of the socioeconomic disparity in TRI facility location is accentuated. Here, TRI facility location is not only associated with high percent minority but also with high rates of poverty and low educational attainment. The fact that population density increases with proximity to, and density of, TRI facilities, indicates that theses TRI facilities also typically occur in the urban core of Philadelphia, as opposed to suburban or exurban areas. This study finds no evidence for increased manufacturing employment with TRI facility location either in the state-wide or southeast Pennsylvania analyses.

Conclusion

The answer to why these patterns in socioeconomic character and TRI facility location exist is complex. A number of authors have argued that interpretations of the statistical evidence of environmental injustice cannot be divorced from an understanding of the underlying social and industrial processes that have produced the statistical evidence (Gelobter 1994, Heiman 1996, Pulido 2000). This study suggests that urban and rural land use and demographics are key components in understanding socioeconomic inequity in the distribution of TRI facilities in Pennsylvania. While it can be argued that these results merely reinforce the idea that hazardous facilities tend to locate in inexpensive and industrial (i.e. urban) lands, Pulido (2000) notes that these market forces are not completely distinct from processes of racism, even if this racism is not overt or even intentional. For example, land value not only influences who can afford to live in a neighborhood, but, conversely, is itself influenced by who lives in the neighborhood; "white" neighborhoods are more valuable partly by virtue of the fact that they are white (Pulido 2000).

The statistical analysis presented here should spur further research into the underlying causes of the socioeconomic inequity in TRI facility location in Pennsylvania. Since this study suggests that urban versus rural land use and associated demographic patterns are important factors in understanding issues of environmental justice in Pennsylvania, future analyses should seek to incorporate data on urbanization and land use explicitly within statistical assessments of environmental inequity. In addition, as Pulido (2000) notes, an historical study of the driving forces of currently observed demographic and TRI facility location patterns in Pennsylvania would provide a much richer context for conceptualizing environmental justice. Unfortunately, this type of study is typically much more cumbersome and time-consuming than a statistical analysis of readily available digital, quantitative data. However, historic census data in digital format has been developed for Philadelphia (see data.library.upenn.edu/phila.html), and the EPA has voluminous (though complicated) digital records of historic environmental compliance and enforcement for individual hazardous facilities. Future investigations of environmental justice should utilize these data sources to uncover the chronological progression, and thus the underlying causes, of patterns of socioeconomic inequity in the distribution of environmentally hazardous facilities in Pennsylvania.

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Table 1. OLS Regression of Distance to Nearest TRI Facility (log), Pennsylvania

Ind. Variables	Model 1	Model 2	Model 3	Model 4	Model 5
% Minority	-0.310***	-0.266***	-0.253***	-0.253***	-0.252***
% Poverty	-	-0.070***	-0.117***	-0.117***	-0.117***
% Degree	-	-	-0.099***	-0.099***	-0.099***
% Manufacturing	-	-	-	0.000	-
Pop. Density	-	-	-	-	-0.009
Adjusted R^2	0.10	0.10	0.11	0.11	0.11
N	3055	3055	3055	3055	3055

* = p < 0.05, ** = p < 0.01, *** = p < 0.005

Table 2. OLS Regression of Density of TRI Facilities (square root), Pennsylvania

Ind. Variables	Model 1	Model 2	Model 3	Model 4	Model 5
% Minority	0.413***	0.391***	0.378***	0.379***	0.377***
% Poverty	-	0.035	0.083***	0.086***	0.083***
% Degree	-	-	0.101***	0.104***	0.102***
% Manufacturing	-	-	-	0.008	-
Pop. Density	-	-	-	-	0.012
Adjusted R^2	0.17	0.17	0.18	0.18	0.18
N	3055	3055	3055	3055	3055

* = p < 0.05, ** = p < 0.01, *** = p < 0.005

Table 3. OLS Regression of Distance to Nearest TRI Facility (log), southeast Pennsylvania

Ind. Variables	Model 1	Model 2	Model 3	Model 4	Model 5
% Minority	-0.290***	0.084	0.107*	0.114*	0.171***
% Poverty	-	-0.487***	-0.425***	-0.417***	-0.393***
% Degree	-	-	0.168***	0.174***	0.138***
% Manufacturing	-	-	-	0.022	-
Pop. Density	-	-	-	-	-0.190***
Adjusted R^2	0.08	0.18	0.20	0.19	0.22
N	984	984	984	984	984

* = p < 0.05, ** = p < 0.01, *** = p < 0.005

Table 4. OLS Regression of Density of TRI Facilities (square root), southeast Pennsylvania

Ind. Variables	Model 1	Model 2	Model 3	Model 4	Model 5
% Minority	0.371***	-0.057	-0.085*	-0.105*	-0.180***
% Poverty	-	0.556***	0.481***	0.458***	0.434***
% Degree	-	-	-0.205***	-0.225***	-0.160***
% Manufacturing	-	-	-	0.068*	0.002
Pop. Density	-	-	-	-	0.284***
Adjusted R^2	0.14	0.26	0.29	0.30	0.35
N	984	984	984	984	984

* = p < 0.05, ** = p < 0.01, *** = p < 0.005

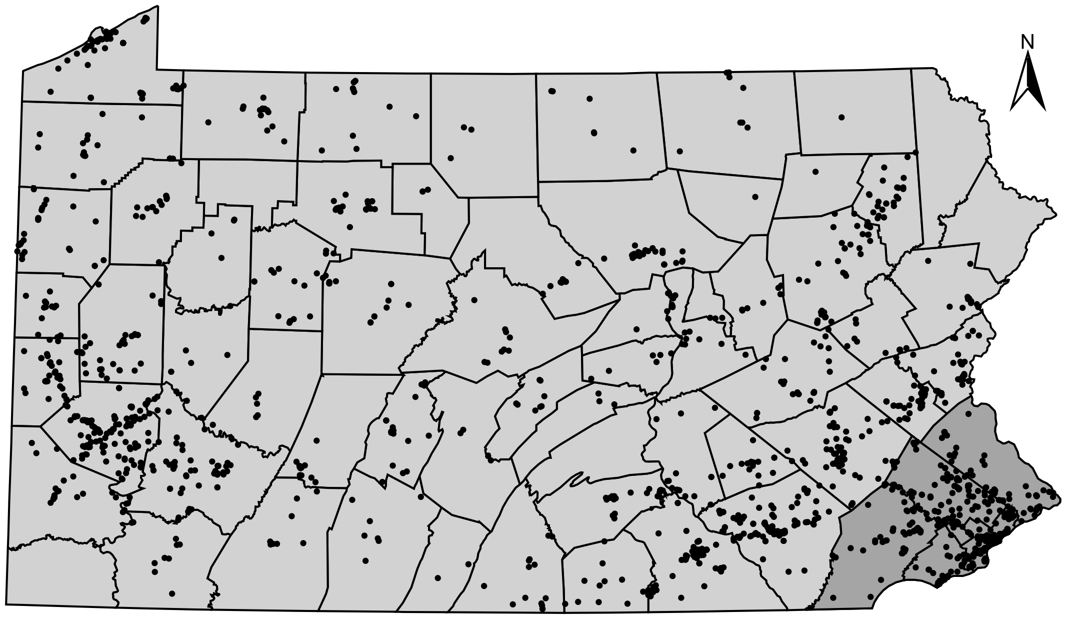

Figure 1. Pennsylvania counties and TRI facility locations. Counties within the southeast Pennsylvania study area are shaded a darker gray.