The Chicago VOC Trading Program 2000-2007: Hot Spots and Environmental Justice

Carol Tallarico
Dominican University

Through the use of a dataset incorporating 2000 census demographic variables by zip code and VOC emissions data by zip code for the years 2000-2007 this paper determines that the zip codes that experienced increased emissions after the implementation of the ERMS program are not systematically related to demographic variables such as income, age, race, and population density. In fact, years of traditional regulations have lead to an unequal distribution of emissions by race and income which improved under the implementation of the cap-and-trade program. These results hold true when using both the entire data set of Chicago area zip codes (N=284) and the smaller data set (N=95) including only those zip codes containing VOC emitting firms. These results cannot be explained solely by the overall decline in emissions of about 60% because the coefficient values fell by over 80% meaning that the difference can be attributed to the change in the distribution of emissions. The changes in the distribution of emissions around the area can either help or hurt certain groups, but these changes do not occur due to a systemic bias that results from using a cap-and-trade system for regulatory control in place of traditional command-and-control regulations.

INTRODUCTION

The US Environmental Protection Agency (USEPA) defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (http://www.epa.gov/compliance/basics/ej.html). The US EPA further defines **fair treatment** as "no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies" (http://www.epa.gov/compliance/basics/ej.html). In its Interim Environmental Justice Policy the Illinois Environmental Protection Agency (IEPA) defines environmental justice as:

> the principle that all people should be protected from environmental pollution and have the right to a clean and healthy environment. It is the protection of the people of Illinois and its environment, equity in the administration of the State's environmental programs and the provision of adequate opportunities for meaningful involvement of all people

> with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (http://www.epa.gov/compliance/basics/ej.html).

One of the key goals of this policy is “to ensure that communities are not disproportionately impacted by degradation of the environment or receive a less than equitable share of environmental protection and benefits” (http://www.epa.state.il.us/environmental-justice/policy.html). Generally, recent research has found that the overwhelming bulk of evidence supports the "environmental justice" belief that environmental hazards are inequitably distributed by class, and especially race (Brown, 1995). The purpose of this paper is to determine if the Environmental Reduction Market System (ERMS) has lead to disproportionate impacts of affected populations by comparing the changes in emissions by zip code from the baseline period (1994-96), the pre-market period (1998-99) and the post-market period (2000-07).

The ERMS program is a cap-and-trade environmental market implemented to reduce volatile organic compound (VOC) emissions in the Chicago ozone non-attainment region. The program began in 2000 with a goal of reducing emissions approximately 12% around the region. In fact, emissions have been reduced by much more, somewhere between 40% to 60% depending on the year. Given this huge overall reduction in emissions it would seem that the program has done an excellent job. However, there are still sub-areas within the non-attainment region experiencing increases in emissions. This is a potential environmental justice concern given that in its human health risk-rankings of environmental health stressors, the California Comparative Risk Project ranks volatile organics among “high ranked risks” and states that those living near emission sources are a population of disproportionate risk of high impact. The study also cites two types of risk, individual risk, one person's added risk of experiencing adverse effects, and population risk, the number of people in an exposed population who might experience adverse effects (CCRP, 1994). In the Chicago region, the population density is very diverse as shown by figure 7 in the appendix. The density ranges from 4 to almost 40,000 people per square mile. Clearly due to these differing population densities increased emissions in some areas will have far greater impacts than increased emissions in others.

The goal of this paper is to determine the sub-areas that experienced increased emissions after the implementation of the ERMS program and to determine if those increases are systematically related to demographic variables such as income, age, race, and population density.

TRADITIONAL REGULATIONS VERSUS MARKET INCENTIVES

Compared with traditional regulations, the autonomy and anonymity of transactions in the cap-and-trade market make increases in emissions in sub-areas more difficult to predict thus raising concerns about spatial impacts. In a competitive cap-and-trade market in which firms have varying marginal pollution control costs, it is expected that firms will reduce emissions by various percentages, implying that it should be advantageous for some firms to increase emissions over their allotment (Montgomery, 1972). As the micro-decisions about reducing emissions or trading are now in the hands of the emitters, independent of the regulating agency, the spatial pattern of emissions becomes evident only at the end of each trading period. For this reason, many environmentalists argue against cap-and-trade markets or actively argue that the markets should be divided to ensure that specific sub-areas cannot experience increases in emissions. However, a unified spatial market was adopted in the Chicago VOC trading program in the interest of maximizing potential control-cost savings from trading.

Under this cap-and-trade policy continuing traditional regulations set a pre-trading ceiling on an individual emitter's emissions that would appear to prohibit any sub-area increases over that level, but it is possible for these increases to occur if existing firms expand production or if new firms move into the sub-area. Neither the expanded or new firm would be allocated additional tradable credits but they could buy permits in the market. There are no restrictions on the market that would prevent such increases from occurring. On the contrary, it is expected that firms that can reduce emissions cheaply will do so and sell permits to firms for whom reducing emissions is more expensive than purchasing permits, thus achieving cost savings in comparison with traditional regulations (Kruger, McLean, and Chen 2000).

Generally, people think that traditional regulations lead to an equitable distribution of emissions, since they affect all firms equally, however this is untrue. Figure 8 in the appendix clearly shows that years of traditional regulations have led to a very unequal distribution of emissions with clusters occurring on the west and south sides of Cook County in densely populated areas. Future implementations of traditional regulations could also lead to increases in emissions since traditional regulations usually determine the specific control technologies required, which often limit the rate of emissions rather than the total amount. Increases in hours of production or additional firms moving into the area can lead to increases in sub-area emissions under traditional regulations. Under a cap-and-trade market the total amount of emissions over the entire area is controlled, but emissions can increase in specific sub-areas if firms choose to purchase emission credits. Thus, increases in sub-area emissions over the baseline can occur under both traditional and market-incentive regulation making a careful empirical before and after analysis required in both cases. It is also important to note that traditional regulations remained in effect even after the ERMS program was put into place.

DATA DEFINITIONS AND SOURCES

Baseline emissions data and location information were obtained from Illinois EPA Title V permits for each firm. Each permit contains the firm's location information as well as information on the firm's baseline and allocation. The 1998-99 seasonal emissions were provided to the author by the Illinois EPA. Firm level seasonal emissions data for 2000-2007 were obtained from the Illinois EPA ERMS ATU Ownership Reports. The IEPA website provides ownership tracking information for each individual allotment trading unit (ATU). Based on this tracking information emissions and allocations for each firm were aggregated for each year 2000-2007. Airborne VOC concentrations must be estimated by the point of source emissions since there are only two monitoring sites for airborne VOC concentrations located in the Chicago metropolitan area. Demographic information was obtained from the Census 2000 Demographic Profile Highlights. More recent data are unavailable. Further details on sources and measurement are provided in table 1.

TABLE 1
DATA DEFINITION AND SOURCES

Variable	Source	Notes
Percent of Population under Age 5	Census 2000 Demographic Profile Highlights	Data available by county and zip code.
Percent of Population Over Age 65	Census 2000 Demographic Profile Highlights	Data available by county and zip code.
Percent of Population that is White (single race)	Census 2000 Demographic Profile Highlights	Data available by county and zip code.
Median Household Income in $1999	Census 2000 Demographic Profile Highlights	Data available by county and zip code.
Per Capita Income in $1999	Census 2000 Demographic Profile Highlights	Data available by county and zip code.
Percent of Individuals living in Poverty	Census 2000 Demographic Profile Highlights	Data available by county and zip code.
Population Density	Population data from Census 2000 DemographicProfile Highlights. Area data from CACI International Inc., ArcView ®,	Population / Area in square miles. Measured as the number of individuals per square mile. Data available by county and zip code.
Baseline Emissions	Firm baselines obtained from Illinois EPA Title V Permits	Average of 2 years 1994-96 seasonal VOC emissions. Possible average of any 2 years 1990-97 if 1994-96 period was atypical. Aggregated to zip code level based on firm locations. Measured in ATUs.
Average 1998-99 Emissions	Firm emissions data provided to author by Illinois EPA	Firm seasonal emissions in 1998-99 aggregated by zip code then averaged over the two years. Measured in ATUs.
Average 2000-07 Emissions	Firm emissions data obtained from Illinois EPA ERMS website	Firm seasonal emissions in 2000-07. Aggregated by zip code then averaged over the 8 years. Measured in ATUs.

DETERMINATION OF THE SUB-AREA

The Chicago non-attainment region covers all of Cook, DuPage, Kane, Lake, McHenry and Will counties. In addition, Aux Sable and Goose Lake townships in Grundy County and Oswego township in Kendall County are also included. There are 118 townships averaging 32 square miles in area, approximately 300 zip codes varying in area but averaging 13 square miles, and hundreds of census tracts varying widely in area.

The counties appear too large in area to reveal hot spots in the detail required. Almost all of the counties reveal a decrease in emissions from baseline in all years. The only exceptions are Kendall County, which experienced increases in emissions of in 2003, 2004, and 2005 and McHenry County which experienced increases in emissions in 1998 and 1999. Kendall County has only one emitter that is part of the ERMS program located in its boundaries so all of the increases in emissions in the county are due to increases in emissions by this single source. The increases in McHenry County occurred before the ERMS market was implemented so these increases occurred under traditional regulations. In sum, if one were to explore the hot spot issue solely from the county perspective it would appear as though there is not a problem.

The townships, a local government area, have been analyzed by the IEPA but their large area and population also leave scope for more detail, specifically in terms of environmental justice issues. For example, township 3912 located in Cook county about halfway up the border of DuPage county contains two zip codes of a very diverse nature. Code 60305 located in River Forest is over about 90% white with a median household income of almost $90,000 and income per capita of almost $50,000. By comparison, code 60153 in Maywood is 90% minority populated, has a median household income of around $40,000 and an average per capita income of less than $15,000. Aggregating these codes together and analyzing the issue by township practically ensures that no environmental justice issues will ever be raised. In addition, the US Census does not track demographic data at the township level, making analysis of environmental justice issues at this level very difficult. Additional information on increases in emissions by township can be found in the yearly Annual Performance Review Reports of the Emissions Reduction Market System published by the Illinois EPA.

In an effort to move toward smaller and smaller neighborhood delineations in order to detect hot spots and more accurately assess environmental justice issues, one must also consider that if the area becomes too small hot spots will only be detected at the plant specific level. In this sense, the census tract appears to provide too much detail for clear mapping analysis and portrayal.

The zip code, a US Postal Service area for mail delivery, appears to be the best compromise in terms of area and neighborhood delineation. The zip code has been chosen as the sub-area for other studies of hot spots as in the California Comparative Risk Project (1994). It also is a spatial unit for which population and socio-economic data are available from the Census 2000 Demographic Profile Highlights. There are 284 zip codes in the eight county area for which complete emissions and demographic data are available. Of these 284, 95 contain emitting firms that are participants in the ERMS program.

ZIP CODE DATA

Using all of the firm level data, emissions data were aggregated by zip code. Table 2 lists summary statistics for the zip code level data. There are two sets of zip code data we will be

examining. The first set (N=284) includes all zip codes in the Chicago eight county metropolitan area for which there was a complete data available. Many of these zip codes do not contain any firms that are part of the ERMS trading program. This implies that there are either no VOC emitting firms in the area or that the firm's seasonal emissions are below 10 tons, the minimum required for market participation. The second set of data (N=95) includes only the zip codes which contain ERMS participating firms.

TABLE 2
ZIP CODE DATA SUMMARY STATISTICS

Variable	Mean	Minimum	Maximum	Standard Deviation	N
Percent of Population Under Age 5	7.09	0.00	12.80	1.84	284
Percent of Population Over Age 65	11.16	0.00	31.20	4.83	284
Percent of Population that is White (single race)	74.46	0.60	98.60	25.58	284
Median Household Income in $1999	59,355.90	0.00	200,001.00	22,405.70	284
Per Capita Income in $1999	27,322.50	9,522.00	99,087.00	13,106.70	284
Percent of Individuals living in Poverty	7.56	0.00	46.30	7.99	284
Population Density	5,151.64	4.00	38,489.00	6,381.96	284
Baseline Emissions	376.81	0.00	19,199.80	1,376.02	284
Average 1998-99 Emissions	204.37	0.00	7,299.50	699.25	284
Average 2000-07 Emissions	151.64	0.00	6,231.25	521.07	284
Percent of Population Under Age 5	7.51	3.70	11.50	1.66	95
Percent of Population Over Age 65	10.78	4.90	28.10	4.08	95
Percent of Population that is White (single race)	67.35	0.60	98.00	29.16	95
Median Household Income in $1999	53,201.90	19,718.00	94,334.00	15,849.10	95
Per Capita Income in $1999	23,306.40	9,522.00	64,330.00	9,184.79	95
Percent of Individuals living in Poverty	9.76	1.50	42.10	9.14	95
Population Density	5,211.75	47.00	33,101.00	6,136.39	95
Baseline Emissions	1,126.46	0.00	19,199.80	2,201.59	95
Average 1998-99 Emissions	610.95	0.00	7,299.50	1,104.99	95
Average 2000-07 Emissions	453.32	0.00	6,231.25	824.14	95

In the Appendix, figures 1-7 provide maps of the Chicago region for a visual analysis of the spatial distribution of the demographic variables by zip code. Similarly, figures 8-10 show the spatial distribution of emissions by zip code for the baseline, pre-market, and post-market periods.

The correlation coefficients between each of the demographic variables and the baseline emissions, average pre-market 1998-99 emissions, and average post-market 2000-07 emissions for each of the two data sets are shown in tables 3 and 4. Table 3 shows the correlation matrix for all of the Chicago area zip codes (N=284) while table 4 shows the correlations for the zip codes with ERMS emitters (N=95). The percentage of population that is white is significantly positively correlated with income and significantly negatively correlated with poverty and population density both data sets. In addition, income is significantly negatively correlated with

poverty in both data sets as we would expect. Finally, all of the emissions variables are significantly positively correlated with each other. We only find significant relationships between emissions and demographics in the full data set (N=284), where emissions are significantly negatively related to income and positively associated with poverty.

TABLE 3
CORRELATION MATRIX (N=284)

	2	3	4	5	6	7	8	9	10
1. Pct. of Pop. Under Age 5	**-0.51**	**-0.22**	-0.09	**-0.36**	**0.26**	-0.05	**0.13**	0.08	0.11
2. Pct. of Pop. Over Age 65		0.11	-0.04	**0.14**	-0.11	-0.05	-0.04	0.00	-0.02
3. Pct. of Pop. that is White			**0.53**	**0.40**	**-0.80**	**-0.47**	-0.07	-0.04	-0.05
4. Median HH Income				**0.83**	**-0.60**	**-0.36**	**-0.13**	-0.09	**-0.12**
5. Per Capita Income					**-0.42**	-0.03	**-0.15**	-0.11	**-0.14**
6. Pct. of Individuals living in Poverty						**0.57**	**0.13**	0.07	**0.12**
7. Pop. Density							-0.02	-0.03	-0.04
8. Baseline Emissions								**0.51**	**0.92**
9. Average 1998-99 Emissions									**0.49**
10. Average 2000-07 Emissions									

TABLE 4
CORRELATION MATRIX (N=95)

	2	3	4	5	6	7	8	9	10
1. Pct. of Pop. Under Age 5	**-0.62**	**-0.42**	**-0.39**	**-0.62**	**0.44**	0.16	0.14	0.03	0.09
2. Pct. of Pop. Over Age 65		0.17	0.00	0.13	**-0.21**	-0.16	-0.03	0.04	0.00
3. Pct. of Pop. that is White			**0.75**	**0.60**	**-0.82**	**-0.54**	0.00	0.07	0.06
4. Median HH Income				**0.76**	**-0.82**	**-0.53**	-0.15	-0.03	-0.10
5. Per Capita Income					**-0.56**	-0.15	-0.18	-0.04	-0.13
6. Pct. of Individuals living in Poverty						**0.62**	0.09	-0.02	0.06
7. Pop. Density							-0.05	-0.07	-0.09
8. Baseline Emissions								**0.42**	**0.90**
9. Average 1998-99 Emissions									**0.39**
10. Average 2000-07 Emissions									

Notes: Coefficients in bold are significant at the 95% level of confidence.

RESULTS

In order to determine if the spatial distribution of emissions has changed over time in relation to the demographic variables 42 total regressions were run using the demographic variables as explanatory variables in determining baseline emissions, average 1998-99 pre-market emissions, and average 2000-07 post-market emissions. In each estimation only one demographic variable was used to explain the level of emissions since the inclusion of more leads to multicollinearity problems due to the high correlations between demographic variables. Each estimation was repeated twice, once for the full data set of all zip codes in the Chicago area (N=284) as shown in table 5 and once for the set of zip codes that contain emitters (N=95) as shown in table 6. The estimations in table 5 were done using Tobit analysis since so many zip codes have zero emissions while the regressions in table 6 were run using OLS.

Clearly, none of these regressions will actually explain the amount of emissions in an area. Emissions will be determined on a firm level basis by things such as demand for products, technological factors, economic performance, and a whole host of other things. However, by examining how the coefficients and t-statistics for these demographic variables changed over the three periods: baseline, pre-market, and post-market we can begin to determine how the relationship between emissions and demographics changed over time.

The percent of population under age 5 has a significant positive effect on emissions in each of the three periods baseline, pre-market, and post-market when using the full data set of all zip codes in the Chicago area (N=284) as shown in table 5. The estimated coefficient falls as we move forward over time from the baseline period to the pre-market period to the post-market period. This fall is in the coefficient value implies that although areas more heavily populated by children tend to have higher level of emissions, that relationship is losing strength. This would imply that the market is moving emissions away from areas heavily populated by children who tend to have higher health risks as shown by Bearer (1995). For the other data set of all emitting zip codes (N=95) shown in table 6, the percent of population under age 5 has a positive relationship with emissions, but it is not statistically significant.

The percent of population over age 65 has a negative relationship with emissions in all cases but one. A positive coefficient is found determining pre-market emissions when using the emitting zip codes data set (N=95) as shown in table 6. None of these coefficients are significant or even close to attaining significance, thus there appears to be no relationship between the elderly and the level of emissions.

The percent of population that is white (single race) has a significant negative relationship with emissions when using the full data set of all Chicago area zip codes. However, the magnitude of the negative coefficient gets smaller as we move forward over time. This implies that emissions are moving away from minority areas toward white areas. Namely, that the distribution of emissions by race around the area is becoming more even as emissions fall in the region. When using the smaller data set (N=95) the coefficient of the percent of population that is white is positive, but completely insignificant.

Population density has a negative relationship with emissions in both data sets. None of these coefficients are significant or even close to attaining significance. There is no relationship between population density and the level of emissions.

TABLE 5
TOBIT ESTIMATES OF EMISSIONS USING ALL CHICAGO AREA ZIP CODES

	Baseline Emissions Tobit	*Average Pre-Market (1998-99) Emissions Tobit*	*Average Post-Market (2000-07) Emissions Tobit*
Constant	-4145.6700	-2113.0000	-1462.8700
	(-4.0020)***	(-3.4945)***	(-3.7993)***
Percent of Population under Age 5	358.9770	165.6000	121.6100
	(2.6264)***	(2.1370)**	(2.3796)**
Constant	-1040.2800	-661.1500	-448.8500
	(-1.5873)	(-1.8690)*	(-1.7941)*
Percent of Population over Age 65	-49.0009	-23.8082	-13.0362
	(-0.8834)	(-0.7749)	(-0.6217)
Constant	-112.8040	-285.5490	-85.4064
	(-0.1442)	(-0.6920)	(-0.2952)
Percent of Population that is White (single race)	-20.1523	-8.7494	-7.0058
	(-2.0383)**	(-1.6011)	(-1.9514)*
Constant	-1558.4900	-911.2260	-572.2270
	(-4.6561)***	(-4.7525)***	(-4.5612)***
Population Density	-0.0045	-0.0018	-0.0039
	(-0.1067)	(-0.0778)	(-0.2601)
Constant	830.6180	204.9510	245.6010
	(0.9965)	(0.4366)	(0.8042)
Median Household Income $1999	-0.0417	-0.0196	-0.0145
	(-2.9162)***	(-2.3388)**	(-2.8462)***
Constant	748.9360	109.2460	194.2280
	(1.2209)	(0.3114)	(0.8089)
Per Capita Income $1999	-0.0890	-0.0396	-0.0300
	(-4.0840)***	(-2.9636)***	(-3.5921)***
Constant	-2165.6800	-1190.0200	-807.3210
	(-6.2966)***	(-5.5401)***	(-6.3788)***
Percent of Individuals living in Poverty	75.1199	33.3624	27.3607
	(2.6510)***	(1.9945)**	(2.7544)***
N	284	284	284

Notes: Numbers in parentheses are t-statistics. *denotes significance at the 90% level of confidence. ** denotes significance at the 95% level of confidence. ***denotes significance at the 99% level of confidence.

TABLE 6
OLS ESTIMATES OF EMISSIONS USING ERMS PARTICIPATING ZIP CODES

	Baseline Emissions OLS	*Average Pre-Market (1998-99) Emissions OLS*	*Average Post-Market (2000-07) Emissions OLS*
Constant	-315.3550	460.5090	103.2620
	(-0.3007)	(0.8662)	(0.2614)
Percent of Population under Age 5	191.8920	20.0220	46.5898
	(1.4076)	(0.2897)	(0.9074)
Adjusted R-squared	0.0103	-0.0098	-0.0019
Constant	1317.4300	480.0640	460.1830
	(2.0441)**	(1.4847)	(1.9063)*
Percent of Population over Age 65	-17.7080	12.1366	-0.6360
	(-0.3166)	(0.4325)	(-0.0304)
Adjusted R-squared	-0.0097	-0.0087	-0.0107
Constant	1108.9600	426.3570	347.4010
	(1.9317)*	(1.4836)	(1.6191)
Percent of Population that is White (single race)	0.2598	2.7407	1.5727
	(0.0332)	(0.6994)	(0.5375)
Adjusted R-squared	-0.0107	-0.0055	-0.0076
Constant	1223.2300	680.8450	515.1190
	(4.1020)***	(4.5555)***	(4.6264)***
Population Density	-0.0186	-0.0134	-0.0119
	(-0.4998)	(-0.7203)	(-0.8547)
Adjusted R-squared	-0.0080	-0.0051	-0.0029
Constant	2224.5000	719.3560	731.6320
	(2.8144)***	(1.7940)*	(2.4578)**
Median Household Income $1999	-0.0206	-0.0020	-0.0052
	(-1.4489)	(-0.2820)	(-0.9751)
Adjusted R-squared	0.0116	-0.0099	-0.0005
Constant	2113.8900	727.2670	721.4270
	(3.4517)***	(2.3308)**	(3.1231)***
Per Capita Income $1999	-0.0424	-0.0050	-0.0115
	(-1.7318)*	(-0.4004)	(-1.2466)
Adjusted R-squared	0.0208	-0.0090	0.0059
Constant	920.3020	637.0400	400.4920
	(2.7733)***	(3.8110)***	(3.2174)***
Percent of Individuals living in Poverty	21.1205	-2.6732	5.4125
	(0.8491)	(-0.2134)	(0.5801)
Adjusted R-squared	-0.0030	-0.0103	-0.0071
N	95	95	95

Median household income has a negative relationship with emissions in all of the estimations. The effect is only significant when using the large data set for all zip codes in the Chicago area. However, the magnitude of the coefficient is getting smaller as we move from baseline to pre-market and then post-market emissions. This implies that the distribution of emissions by income is becoming more even due to the large drop in emissions in the emitting zip codes.

Per capita income has a negative relationship with emissions in all of the estimations. The effect is significant when using the large data set for all zip codes in the Chicago area. However, the magnitude of the coefficient is getting smaller as we move from baseline to pre-market and then post-market emissions, implying that the distribution of emissions by income is becoming more even due to the large drop in emissions in emitting zip codes. In the smaller data set this negative relationship is significant in the baseline period in the data set of zip codes with emitters. This significant relationship disappears as we move forward through time. This implies that the distribution of emissions has become more even with respect to income since the implementation of the market among the 95 emitting zip codes.

The percent of individuals living in poverty has a significant positive relationship with emissions when using all of the Chicago zip codes. Again the coefficient is diminishing in size as we move from the baseline period to the post-market period. This again implies that the distribution of emissions with respect to poverty is becoming more equal due to the large drop in emissions in emitting zip codes. In the smaller data set, the coefficient is positive in the baseline and post-market period, but never significant.

CONCLUSION

When using the full data set of all zip codes in the Chicago area (N=284) we find that the percent of population under age 5 and the percent of individuals living in poverty have a significant positive relationship with emissions in all periods. The percent of population that is white, the median household income, and per capita income are significantly negatively related to emissions in all periods. These results imply that generally emissions are higher in areas that are poorer, more populated by minorities, and have a predominance of children. These results would conform to what has been found in the past regarding environmental justice concerns, namely that the brunt of the negative externality of pollution will be borne by the poor and minorities. This result stems from the fact that many zip codes included in these estimations do not have any emitters located within them.

Although these results conform to what would already be expected, that emissions are higher in poor areas, what I am more interested in is whether the market made this distribution better or worse. Years of traditional regulations, as shown by the baseline emissions regressions, have lead to an unequal distribution of emissions by race and income. This result occurred under complete government oversight and control. The question then, is how did the distribution change under more limited government control in the form of a cap-and-trade system? The results show that the cap-and-trade system made the distribution more equitable. The changes in size of the coefficients when we compare the baseline period to the post-market period show that emissions are becoming more equally distributed by race and income. This result is not just due to the overall decline in emissions. Overall emissions fell by about 60% between the baseline and post-market time period, but all of the coefficient values fell by over 80% meaning that the difference can be attributed to the change in the distribution of emissions.

On another level, when we use the data set of only zip codes with emitters (N=95) we find that generally there is no relationship between the demographic variables and emissions in any of the time periods. The only significant effect found is the negative effect of per capita income on baseline emissions. The effect then becomes insignificant in the post-market period, again implying that if anything the market helped make the distribution of emissions more equal rather than less.

In summary, emissions are located where they are due to a host of economic factors. Firms do not make their emissions decisions based on the demographics of the neighborhood in which they are located. Firms make production decisions which are determined by economic factors, which then lead to emissions as a by-product. If the distribution of emissions changes to either help or hurt certain groups it is an accident of economic adjustments not a systemic bias that results from using a cap-and-trade system for regulatory control in place of the traditional command-and-control regulations.

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