ENVIRONMENT

Have the poor and minorities gained or lost from efforts to cut pollution?

The Beneficiaries of Clean Air Act Regulation

By Matthew E. Kahn
Tufts University

Ambient air quality in the United States has improved dramatically in the last 20 years. Despite population growth, reduced utilization of public transit, and increased vehicle use per-capita, emissions per unit of economic activity are falling faster than economic activity has grown. This translates into a reduced exposure to air pollutants for the average person.

We know that the "average" person is experiencing a decrease in air pollution, but we do not know much about the distributional effects of regulation-induced reduction. Have the poor, as well as the wealthy, significantly reduced their exposure to pollutants? Are minorities paying the cost for these regulations as pollution-intensive industries cut their workforce or move away?

This article will try to answer these questions by looking at air quality and demographic data from California, a state with a diverse population and with a significant amount of air pollution regulation. Using state data on how the spatial distribution of pollution has changed between 1980 and 1998, and federal data on the spatial distribution of the population in 1990, we can determine which demographic groups have experienced the greatest reductions in pollution exposure and we can theorize who has paid the price for these reductions.

AMBIENT AIR POLLUTION TRENDS

California historically has had the worst air quality in the nation. As part of the effort to reverse this, the state established an extensive network of monitoring stations that measure ambient air pollution. This network provides us with nearly two decades (1980 to 1998) of site-specific data for concentrations of the ambient pollutants carbon monoxide, nitrogen dioxide, ozone, and sulfur dioxide. Additionally, there is a decade of data (1988 to 1998) on concentrations of particulate matter. These pollutants, along with lead, represent the six air pollutants regulated under the Clean Air Act.

To examine the distributional effects of air pollution regulation in California, I have gathered data on pollutant concentrations inside and outside the state's Los Angeles basin. I distinguish between inside and outside because the basin has the worst air quality in the nation and because it is subject to especially stringent air quality regulations. I believe that, by comparing statistics from inside and outside the basin, we can better see the distributional effects of this regulation.

In Table 1, we see a snapshot of California's progress in reducing the amount of air pollution in both of these geographic areas. According to these statistics, the levels for all five pollutants have dropped significantly throughout California, but the decrease is greater inside the basin. Between 1980 and 1998, ambient sulfur dioxide levels fell by 8.9 percent per year in the L.A. basin as compared to a mere 0.7 percent outside. Ozone levels—which are extremely high in the Los Angeles area—fell a remarkable 12.3 percent per year inside the basin as compared to 4.6 percent for the rest of the state. All of the downward trends, except particulate matter, are greater (with 95 percent confidence) inside the L.A. basin than in the rest of California.

This information strongly suggests that Clean Air Act regulation has reduced air pollution levels in California, and that the more stringent regulations inside the basin have had more effect on pollution levels than the less rigorous

Matthew E. Kahn is an associate professor of international economics at the Fletcher School of Law and Diplomacy at Tufts University. His research interests include environmental and urban policy. Some of his academic work can be found on the Web at www.fletcher.tufts.edu/faculty/kahn.html. He can be contacted by E-mail at matt.kahn@tufts.edu.

JEREMY WOODHOUSE / PHOTODISC, GENE DANIELS / NARA (INSET)

BETTER AIR: Los Angeles experiences significantly fewer high ozone days today (above) than it did two decades ago.

regulations outside. But who has paid for this benefit, and who are the beneficiaries? Let us look more carefully at the California situation and at the state's demographics.

WHO PAID FOR AIR QUALITY IMPROVEMENTS?

WHEN AIR QUALITY REGULATIONS WERE FIRST proposed for California, some policy analysts worried that the poor, less educated, and minorities would shoulder a disproportionate share of the costs for cleaning up the air. These costs could come in the form of increased expense in purchasing and operating personal vehicles, reduced employment opportunities as industry faced new expenses, and unknown effects on land prices and residential rent structures. Have the poor, less educated, and minorities paid for much of the improvement in California's air?

Vehicle use Mobile sources such as cars and trucks contribute heavily to California's air pollution emissions. According to 1995 statistics, mobile sources are responsible for 28 percent of total organic gas emissions (which contribute to ozone formation), 82 percent of carbon monoxide, 80 percent of nitrogen dioxide, and 48 percent of sulfur dioxide. To lower these emissions, California has adopted a number of pollution regulations for both new and used vehicles.

Because the poor are more likely to own older vehicles that produce more emissions, it would initially appear that they would have to pay more of the mobile source cleanup cost. But in fact, this does not seem to be the case; many of the vehicles that produce the most pollution are still on the road. State analysts believe that a remarkable 90 percent of California's mobile source emissions come from a very small segment—10 percent—of the vehicle fleet. Vehicle emissions inspections have not been effective at identifying

Table 1

Annual Percentage Change in Pollutants

POLLUTANT	LOS ANGELES BASIN	OUTSIDE L.A. BASIN
Carbon Monoxide	-3.4%	-3.0%[1]
Nitrogen Dioxide	-2.9%	-2.2%[2]
High Ozone Days	-12.3%	-4.6%[2]
Sulfur Dioxide	-8.9%	-.7%[2]
Particulate Matter[3]	-5.6%	-5.1%

[1] The hypothesis that the two trends are equal is rejected at the 10% statistical significance level.
[2] The hypothesis that the two trends are equal is rejected at the 1% statistical significance level.
[3] Pollution trends for all pollutants except particulate matter are from data from 1980 to 1998. The particulate matter trend is from 1988 to 1998.

Table 2

California Pollution Exposure by Demographic Group

POLLUTANT	DATE	ALL	INCOME LEVEL		EDUCATION		ETHNICITY		
			<30K	>65K[1]	BA	Non BA	White	Black	Hispanic
Carbon Monoxide	1980	8.775	10.792	7.134	7.774	9.043	7.890	11.223	10.658
	1998	4.132	5.312	3.531	3.662	4.263	3.772	5.039	5.059
Nitrogen Dioxide	1980	.169	.191	.144	.159	.171	.160	.174	.195
	1998	.085	.097	.078	.081	.086	.081	.090	.096
Ozone	1980	.103	.098	.101	.101	.104	.106	.081	.111
	1998	.070	.067	.071	.070	.070	.072	.060	.069
High Ozone Days	1980	31.157	31.015	25.213	27.515	32.173	31.799	16.764	40.416
	1998	4.479	3.935	4.587	4.375	4.509	4.770	3.197	4.685
Sulfur Dioxide	1980	.006	.008	.005	.006	.006	.006	.008	.007
	1998	.002	.002	.002	.002	.002	.002	.002	.002
Particulate Matter	1980[2]								
	1998	49.266	57.791	44.516	47.143	49.866	48.593	47.602	54.142

[1] Amounts are in 1990 dollars. [2] Information on particulate matter was not collected until 1988. Exposure = $\sum j$ (share who live in tract j) X (pollution level in tract j)

Carbon Monoxide is measured in parts per million. The statistic is the average of the top 30 maximum eight-hour concentration measurements. Nitrogen Dioxide is measured in parts per million. The statistic is the top daily maximum one-hour concentration measurements. Ozone is measured in parts per million. It is measured as the average of the top 30 daily maximum eight-hour concentration measurements. High Ozone Days is the count of days exceeding the Clear Air Act's national one-hour standard. Sulfur Dioxide is measured in parts per million. Its statistic is the average annual arithmetic mean. Particulate Matter is measured in micrograms per cubic meter. It is measured as the average of the 10 highest daily measurements at a specific site during the year.

and repairing these cars because state lawmakers limited the amount of money a vehicle owner is required to spend to improve his vehicle's emissions. Moreover, vehicles are tested infrequently; the law requires that they be inspected each time they are sold or upon the biennial registration renewal. In addition, independent garages, service stations, and new car dealers supply emissions inspections, and these firms have little incentive to encourage emissions reductions. Instead, such businesses may offer polluting car owners a "free pass" in order to build a relationship with the owner.

But California, overall, is seeing an improvement in mobile source emissions levels, and this appears to be because newer cars have significantly less emissions. The drivers of these newer cars are thus paying for the improvement, and they are paying heavily; the cost of a vehicle has increased by between $1,000 and $2,000 to cover the cost of pollution-fighting equipment. Thus, it seems that the middle and upper classes are paying emissions penalties that many of the poor are avoiding.

Employment Stationary sources also contribute heavily to California air pollution emissions. According to state statistics, 38 percent of California organic gases come from such stationary sources as industrial organic chemical production and petroleum refining. These industries are subject to severe regulation under the Clean Air Act.

It is difficult to measure the effect these regulations have on firm profitability, but researchers have studied the employment impacts in an effort to document any spatial "displacement effects." Clean Air Act regulation is spatially concentrated on high pollution "nonattainment" areas like the L.A. basin. This, in turn, has prompted plants to relocate away from these places to attainment areas where regulation is less stringent and less costly. But, despite this migration of industry, researchers have not found significant negative effects on employment in the tightly regulated L.A. basin. In fact, a forthcoming article from Eli Berman and Linda Bui states that "the local air quality regulations introduced during 1979-92 in the Los Angeles basin were not responsible for a large decline in employment. In fact, they probably increased labor demand slightly." So, it seems that people — rich and poor — who live inside the L.A. basin have not lost employment opportunities because of air pollution regulation.

Residential property costs As regulation improves local air quality, it is possible that real estate prices will rise as potential homeowners and renters become willing to bid more to live in the improving areas. If rents increase, then poorer renters who already live in the improving areas could experience a reduced quality of life if they do not value air quality improvement as much as the extra rent they now pay. This scenario could take place if potential renters can cheaply migrate to the improving areas but construction costs for erecting new units are high enough to restrict building. If this scenario is the case, then environmental regulation would be regressive.

We know that nice areas feature higher rents, but there is little evidence that improving areas experience rising rents over time. Incumbent renters will not face higher real estate prices if migration is costly and if information is slow to spread that a dirty area is now clean. Based on a cross-city analysis of housing data from the 1970s to the 1990s, researchers Katherine Kiel and Jeff Zabel found that home prices are not rising sharply in areas where air quality has improved.

From this discussion, it seems that the poor and minorities are not paying an excessive price for Clean Air Act regulation. They have not experienced significant job loss, increased rental costs, or increased vehicle operation expenses that can be attributed to the regulations. If anything, it is the wealthier purchasers of new vehicles who are picking up a disproportionate amount of the financial burden for improving the air. It could thus be argued that air pollution regulation is distributing the costs progressively. But who is benefiting from these regulations?

WHO GAINED FROM POLLUTION REDUCTION?

TO STUDY POPULATION POLLUTION EXPOSURE requires super-imposing demographic maps over maps of the distribution of pollution. To accomplish this, I used demographic information from the 1990 Census, which includes such statistics as percentage of college graduates and median income for small geographical units of roughly 4,000 people. I then correlated this data with information from California's air pollution monitoring network.

Determining exposure To merge these two bodies of information into a single data set, I determined the distance between each monitoring station and each census tract. If a monitoring station is within 8,000 feet of a census tract, then I assigned the information from that monitoring station to the tract. Census tracts that were not within close proximity to a monitoring station were ignored for the purpose of this study. This assignment procedure allowed me to create a data set of roughly 1,800 census tracts that, together, contain more than 7 million California residents.

Obviously, I would have preferred to derive data for all of the state's census tracts. However, because California tries to place monitoring stations in areas with heavy air pollution, it could be argued that the information I compiled covers the segment of the state's population that most interests us: the portion that has been most affected by air quality regulation.

To measure which demographic groups have gained the greatest benefits from Clean Air Act regulation, I used the compiled data set to calculate the average exposure by demographic group for pollution levels in 1980 and in 1998. For this calculation, I used the following equation:

> exposure = (share of the demographic group that lives in census tract j) X (pollution level in j) + (share of the group that lives in k) X (pollution in k) + (share of the group that lives in l) X (pollution in l) . . .

For example, if 40 percent of the people in a specific demographic group lives in one census tract where the pollution level is 100 units and 60 percent of the people in the group lives in a second census tract where the pollution level is zero units, then the average exposure for the group is 40 units of pollution. The data that I derived are based on a generalization of this equation that takes into account the hundreds of census tracts throughout the state. In these calculations, the population shares (in percent) sum to one.

Exposure per demographic group Table 2 depicts how population pollution exposure has changed as the spatial distribution of pollution changed between 1980 and 1998. Reading across a row reveals differences in pollution exposure for different demographic groups at a specific time.

What we find is that better educated, wealthier populations do experience cleaner air, but that poorer, less educated populations have experienced a greater overall improvement in air quality between 1980 and 1998. For instance, in 1980 the average person who lived in a census tract where the median income was greater than $65,000 (in 1990 dollars) was exposed to 25 percent less nitrogen dioxide than a person who

Table 3

California County Pollution Exposure

POLLUTANT	DATE	ALL	LOCATION		COUNTY INCOME		% OF COUNTY THAT IS HISPANIC	
			L.A. Basin*	Outside L.A. Basin	Above Median	Below Median	Above Median	Below Median
Carbon Monoxide	1980	7.054	9.422	4.769	7.172	3.857	7.328	4.816
	1998	3.297	4.083	2.561	3.341	2.726	3.447	2.173
Nitrogen Dioxide	1980	.144	.192	.097	.146	.070	.151	.084
	1998	.073	.093	.054	.074	.058	.076	.046
Ozone	1980	.105	.140	.073	.106	.077	.110	.067
	1998	.076	.084	.069	.075	.091	.077	.071
High Ozone Days	1980	32.720	61.943	6.094	34.306	2.517	36.734	1.825
	1998	5.525	9.770	1.753	5.595	4.843	6.095	1.605
Sulfur Dioxide	1980	.005	.007	.003	.005	.001	.006	.002
	1998	.002	.002	.002	.002	.003	.002	.002
Particulate Matter	1980							
	1998	50.300	57.426	43.924	49.010	63.184	52.000	39.208

* The Los Angeles basin is defined as encompassing Orange, Riverside, San Bernardino, and Los Angeles counties. Exposure = $\sum j$ (share who live in tract j) X (pollution level in tract j)

lived in a tract where the median income was less than $30,000. However, by 1998, the typical person making less than $30,000 a year was breathing almost as little nitrogen dioxide as the typical person who makes more than $65,000. Overall, the exposure differentials by income for all of the pollutants (except particulate matter, for which 1980 information was unavailable) sharply diminished between 1980 and 1998. The only dramatic disparity between the two economic groups is in exposure to particulate matter.

A similar decrease in exposure differentials over time can be seen for the average college graduate and the average nongraduate. Across all of the pollution indicators (with the exception of sulfur dioxide exposure), the less educated person has experienced a greater pollution exposure reduction for nitrogen dioxide, carbon monoxide, and ozone. Further, both groups have experienced dramatic decreases in the number of high ozone days and in exposure to sulfur dioxide.

The race demographics are especially interesting. In 1980, the average Hispanic person was exposed to nine more high ozone days per year than the average white person, while the typical black person experienced dramatically fewer high ozone days than either whites or Hispanics. This surprising finding could be explained by the fact that Watts—a heavily black populated area—is located in an area with low ozone levels. Despite the good news for ozone, black pollution exposure to the other four pollutants in 1980 is significantly higher than the exposure level for whites.

But, as with income level and education, the disparities between the three racial groups have decreased between 1980 and 1998. With the exception of particulate matter, whites, blacks, and Hispanics were exposed to roughly the same air pollution levels in 1998. Hispanics have been the biggest winners, enjoying the greatest reductions in pollution exposure over the past two decades.

County Exposure Differentials As interesting as these statistics are, they do not provide the full picture of who is benefiting from the Clean Air regulations. This is because Table 2's coverage includes only those people who live near the ambient monitoring stations. To address this issue, I also created a county-level data set of population-weighted mean pollution levels.

Table 3 depicts this data. It shows that residents of the Los Angeles basin, where regulation is especially stringent, experienced a larger pollution exposure reduction than California residents who live outside the area. Surprisingly, the data also indicate that richer counties had worse air quality in 1980 and experienced greater pollution reductions between 1980 and 1998. The final two columns again show that Hispanics lived in the most polluted counties in 1980 but that the percent reduction in Hispanic pollution exposure has been greater than the percent reduction in exposure in counties with a relatively small Hispanic population.

These statistics strongly suggest that the more stringent regulation in nonattainment areas has helped close the disparities in air pollution exposure between racial groups. The data also suggest that stricter regulation has benefited wealthier counties more than poorer counties.

CONCLUSION

AIR QUALITY IS AN IMPORTANT COMPONENT OF A PERson's quality of life. Households that desire cleaner air can achieve this goal either by moving to "cleaner" areas (and paying higher real estate prices for cleaner areas) or by waiting for government regulation to reduce pollution at a given location.

Because the population is not uniformly distributed, spatially concentrated pollution reductions have produced differential effects. In California between 1980 and 1998, Hispanic pollution exposure fell sharply and exposure differentials between richer and poorer people fell sharply. In 1998, only particulate matter exposure is much higher for the poor in comparison with the wealthy. Given the overall trend in improvements for certain demographic groups, it appears that regulation under the Clean Air Act has helped, and not economically harmed, the "have nots." R

READINGS

- "The Cost of Environmental Protection," by Richard Morgenstern, William A. Pizer, and Jhih-Shyang Shih. Resources for the Future Discussion Paper 98-36.
- "The Distribution of Pollution: Community Characteristics and Exposure to Air Toxics," by Nancy Brooks and Rajiv Sethi. *Journal of Environmental Economics and Management*, Vol. 32, No. 2 (February 1997).
- "Effects of Air Quality Regulation," by Vernon Henderson. *American Economic Review*, Vol. 86 (1996).
- "Effects of Air Quality Regulations on Polluting Industries," by Randy Becker and Vernon Henderson. *Journal of Political Economy*, April 2000.
- "The Efficiency and Equity of Vehicle Emissions Regulation: Evidence from California's Random Audits," by Matthew E. Kahn. *Eastern Economic Journal*, Fall 1996.
- "Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin," by Eli Berman and Linda Bui. *Journal of Public Economics*, forthcoming.
- "Estimating the Demand for Air Quality in Four United States Cities," by Katherine Kiel and Jeff Zabel. *Land Economics*, Vol. 76 (2000).
- "Geographics of Smog," by Vernon Henderson. *Regulation*, Vol. 21, No. 3 (Fall 1998).
- "New Evidence on Trends in Vehicle Emissions," by Matthew E. Kahn. *Rand Journal of Economics*, Spring 1996.
- "Social Cost of Environmental Quality Regulations: A General Equilibrium Analysis," by Michael Hazilla and Raymond Kopp. *Journal of Political Economy*, Vol. 98, No. 4 (August 1990).
- "Using Inspection and Maintenance Programs to Regulate Vehicle Emissions," by Thomas Hubbard. *Contemporary Environmental Policy*, Vol. 15, No. 2 (April 1997).