SMOG REDUCTION'S IMPACT ON CALIFORNIA COUNTY GROWTH*

Matthew E. Kahn
Department of Economics, Columbia University, New York, NY 10027, U.S.A.
E-mail:mk214@columbia.edu

ABSTRACT. Over the last twenty years, environmental regulation has sharply reduced pollution levels in the Los Angeles region. Population growth has soared in the Los Angeles suburbs that have experienced the largest pollution reductions. This paper posits that regulation has increased local quality of life which has encouraged in-migration. I explore alternative explanations for this growth.

1. INTRODUCTION

While California's population grew by 27.6 percent between 1970 and 1994, the Los Angeles suburbs have grown much faster. Between 1969 and 1980 Riverside and San Bernardino counties' populations grew by 40.1 percent and their growth accelerated to 84.7 percent between 1980 and 1994. Growth in these Los Angeles suburban counties is notable because they have the worst ozone smog levels in the nation. Ozone is a strong irritant that can cause constriction of the airways, forcing the respiratory system to work harder to provide oxygen. For healthy people it makes breathing more difficult during work and exercise but may pose a worse threat to those who already suffer from respiratory diseases such as asthma, emphysema, and chronic bronchitis (Grant, 1995).

Los Angeles and its suburbs have experienced sharp reductions in pollution over time because new vehicle regulation has sharply reduced vehicle emissions (Kahn, 1996a). Manufacturing regulation has played a role in reducing NOX emissions, an input in ozone production (Berman and Bui, 1998; Becker and Henderson, 1997; Henderson, 1996). In the San Bernardino metropolitan area residents were exposed to 40 fewer high ozone days in 1996 than in 1980. Such an air quality improvement should have a significant impact on quality of life. One health-based study's estimates imply an annual per-capita per-exceedence benefit of $6.50.[1] Based on this estimate,

*I thank three anonymous reviewers for useful comments and suggestions. Mali Chivakul provided excellent research assistance. All errors are mine.

Received December 1998; revised August 1999; accepted November 1999.

[1]Hall et al. (1992) estimate that the Los Angeles basin-wide health benefits of meeting the ozone Clean Air Act best is 2.7 billion dollars. If there are 14 million people in the basin who were

Blackwell Publishers, 350 Main Street, Malden, MA 02148, USA and 108 Cowley Road, Oxford, OX4 1JF, UK.

a household of four people would value this ozone exposure reduction at roughly $1,000.[2]

High pollution levels may have stunted economic development in parts of the Los Angeles region. Pollution reductions make previously low quality of life areas increasingly desirable places to live. This paper documents that California county population growth soared in those counties that experienced the sharpest ozone smog reductions. My thesis is that county quality of life increased in areas where ozone fell sharply and this has encouraged in-migration. Ozone regulation has greatly improved local quality of life by removing a key impediment to the enjoyment of outdoor leisure in an area where land is cheap (the Los Angeles suburbs).

To link regional development to local environmental quality levels, I first present cross-county population growth regressions. These regressions document that the polluted Los Angeles suburbs experienced accelerated population growth after 1980 relative to their earlier growth and relative to concurrent "control" counties. I show that ozone declines are correlated with population growth even controlling for local labor market demand, home prices, and other county attributes. To document quality of life improvements in the Los Angeles suburbs, I use a new data set covering all of California's ambient air quality readings from 1980 to 1996. This data set allows me to study the trends in the spatial distribution of air quality improvements. As the San Bernardino metropolitan area's smog levels have fallen sharply, there has been a rise in the in-migration of retirees and college graduates. The growth of such amenity-seeking migrants is revealed preference evidence that this area's quality of life has improved. Perhaps surprisingly, quality-adjusted home prices have not increased in these areas. Thus, there remains an incentive to migrate to an area featuring improved amenities without higher real land prices.

2. CALIFORNIA COUNTY GROWTH BETWEEN 1969 AND 1994

To begin to study California county growth differentials, I graph county population growth in California between 1969 and 1980 and 1980 to 1994. The data source for California annual county population is the U.S. Department of Commerce's Regional Economic Information System (REIS). In Figures 1 and 2, each of the 58 data points is represented by its geographical FIPS code.

exposed to an average of 30 exceedence days each in 1990, this yields a per-capita benefit of $6.50 per exceedence. This estimate is larger than ozone benefit estimates based on medical care demand estimates. Using Los Angeles data, Dickie and Gerking (1991) estimate how the propensity to seek medical care is affected by ozone exposure. They report a willingness to pay of 170–210 dollars a year for reducing Glendora's ozone exceedences from 117 to 0 days.

[2]The hedonic capitalization literature reports evidence that high ozone areas feature higher compensating differentials through lower real estate prices (Brookshire et al., 1982). Using 1990 Census Micro data for households in Los Angeles, I find that controlling for a host of other local public goods such as crime, public school quality, distance from the CBD, a quality adjusted home that is exposed to ten more days per year of ozone exceeding the national standard is priced 2.5 percent lower (DiPasquale and Kahn, 1999).

Between 1969 and 1980, California counties exhibit a familiar convergence pattern such that counties with smaller populations in 1969 are growing at a faster rate between 1969 and 1980. Between 1980 and 1994 there are two obvious outliers. These counties are Riverside (FIPS #65) and San Bernardino (FIPS #71). It is important to note that these counties were not outliers with respect to population growth between 1969 and 1980. To confirm that this growth differential is statistically significant I estimate Equation (1)

$$\log(Pop_{j,t+1}/Pop_{j,t}) = \gamma \log(Pop_{j,t}) + B X_{jt} + U \tag{1}$$

The dependent variable is a county's population growth. The regression reported in Table 1 has 116 observation. For each of the 58 counties, I model population growth from 1969 to 1980 and from 1980 to 1994 as a function of the log of county population in 1969; a dummy indicating that the observation is for the latter time interval; a Los Angeles region dummy that equals one for Anaheim, Los Angeles, Riverside, San Bernardino, Kern, Ventura, and San Diego; a dummy that equals one for Riverside and San Bernardino; and interactions of these two dummies with the 1980 to 1994 dummy. I estimate the regression to test the hypothesis that population growth in Riverside and San Bernardino accelerated between 1980 and 1994 relative to 1969 to 1980 growth and that this growth is statistically significant. Table 1 shows that the Los Angeles region as a whole had higher population growth than the rest of California during these years. Riverside and San Bernardino experienced sharp population growth between 1980 and 1994 relative to the Los Angeles region and relative to their 1969 to 1980 growth. Their growth was 42.1 percent higher between 1980 and 1994 than between 1969 and 1980.

TABLE 1: California County Population Growth 1969 to 1994

The dependent variable is county population growth from 1969–1980 and 1980–1994.
This regression is based on Equation (1) in the text.

	Beta	Standard Error	*t*-Statistic
Log 1969 County Population	–0.062	0.016	–3.743
1994 Calendar-Year Dummy	–0.074	0.047	–1.569
Los Angeles Region Dummy	0.085	0.064	1.320
San Bernardino and Riverside Dummy	0.058	0.065	0.890
Los Angeles Region Dummy Interacted with 1994 Calendar-Year Dummy	0.108	0.080	1.356
San Bernardino and Riverside Region Dummy Interacted with 1994 Calendar-Year Dummy	0.421	0.086	4.899
Constant	0.661	0.095	6.964
Observations	116		
R^2	.20		

The regression is estimated using OLS and the standard errors have been corrected for county-level correlation.

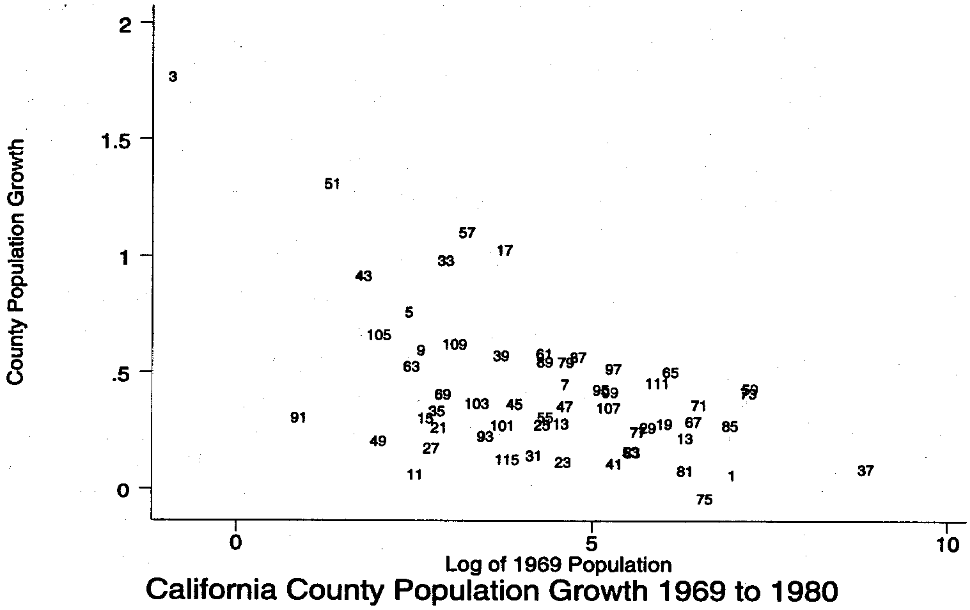

FIGURE 1: California County Growth from 1969 to 1980.

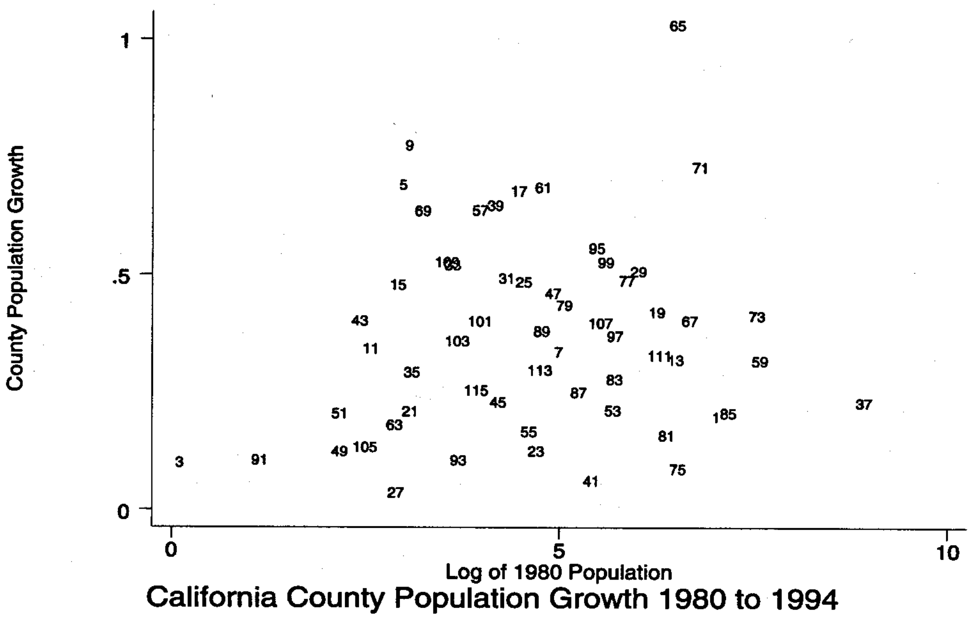

FIGURE 2: California County Growth from 1980 to 1994.

To study what factors might explain this sharp growth between 1980 and 1984, I present county population-growth regressions based on Equation (2)

$$(2) \qquad \log(Pop_{j,1994}/Pop_{j,1980}) = \gamma \mathbf{Z}_j + V_j$$

The **Z** vector includes a set of economic controls to test whether such explanations as the pursuit of cheap housing or local labor market demand can explain cross-county population growth differentials.

The **Z** vector presented in Equation (2) is based on data from REIS CD-rom and the *City and County Data Book* from 1980. Included in the **Z** vector are the percent of the county's inhabitants who are Hispanic, median home prices, the percent of the county's land area devoted to farmland, and a proxy for local labor demand. This proxy variable is calculated using the national growth between 1980 and 1985 in each of the industries whose employment is listed in the REIS data (for example FIRE, services, and manufacturing). I collapse these growth rates into a single index using the county's share of employment in each industry as weights (Bartik, 1991; Blanchard and Katz, 1992; Bound and Holzer, 1996). This index will be higher if a county's employment is over-represented in a particular industry which is growing at the national level.

The popular press has explained Riverside and San Bernardino's growth as being fueled by the pursuit of cheap space.[3]

> "In the last five years, the city's population has nearly doubled to 90,000 as thousands of young and largely upwardly mobile families have decided to trek even farther inland in search of housing bargains. They find pay dirt in Fontana (a city in San Bernardino). New detached single-family homes can be purchased for as little as about $110,000 and nothing costs more than $250,000. . . . Many of Fontana's new residents are first time homeowners and just as many are move up buyers seeking to get more house for their dollar than they can in Los Angeles and Orange Counties." (Lazzareschi, 1989).

County median home prices in 1979 proxy for cheap housing opportunities.[4] In 1979, the median Orange County home cost $44,000 more than the median home in San Bernardino.

As a final variable included in estimating Equation (2) I collected information on the number of days that ozone exceeded the Clean Air Act national one-hour standard which I call "high ozone days" for each county in 1980 and 1994. If a county had 40 high ozone days in 1980 and 32 high ozone in 1994, then its change in high ozone days would be –8.

[3]In the 1970s, California home prices grew sharply. Fischel (1995) attributes a large portion of this growth to growth controls adopted across the state. Constraints on development raised prices in the 1970s in built-up areas in California. California courts became the most anti-development in the nation (Fischel, 1995, p. 226). For more on California growth controls and their impact see Dowall (1984) and Fischel (1990) for an overview on how growth controls affect home prices.

[4]Gabriel, Marquez, and Wascher (1992) present evidence that migrants are responsive to spatial home-price differentials.

The regression presented in Equation (2) features 58 data points. The dependent variable is the growth rate in county population between 1980 and 1994. In Table 2 I report the results of two regressions. The left column fits a county's population growth as a function of its change in ozone, initial farmland, percent Hispanic, local labor demand, and home prices. The county population growth regression results are quite intuitive. Counties grew faster if they contain more farmland, have a larger Hispanic population, experienced growing local labor demand, and if home prices were lower. Holding all else equal, an extra standard deviation of farming raised a county's population growth between 1980 and 1994 by 6 percent.[5] An extra standard deviation of Hispanic population raised growth by 5.5 percent, an extra standard deviation of local labor market growth raised population growth by 12.8 percent, and a standard deviation increase in median county home prices lowered growth by 11.9 percent.[6] Controlling for these other economic factors, California counties grew faster if their ozone levels declined. A county that experienced a 10-day reduction in high ozone days between 1980 and 1994 grew by 7.8 percent more than a county whose ozone level remained unchanged. This estimate may underestimate the true effect because of reverse causality. Sprawl opponents have been concerned that population growth causes degraded air quality. If this effect were large it would bias the effect of ozone improvements on population growth toward zero because population growth leads to greater vehicle mileage which translates into more local smog. I estimated this regression using 1980 ozone levels as an instrument for the change in ozone levels and find quite similar results (results available on request).

The right column of Table 2 presents a second regression specification that drops the ozone variable and includes the San Bernardino and Riverside county dummy. Controlling for the other factors this dummy remains positive and statistically significant. Without any controls its coefficient was 0.520 and with controls it is 0.484. The Los Angeles suburbs population growth cannot be explained by employment, land availability, or it being an immigrant enclave, alone.

Although Riverside and San Bernardino county growth has been above the regression prediction, other Los Angeles region counties such as Kern or Ventura have not experienced differentially high growth.

I also estimated additional population growth regressions which include proxies for home prices in adjacent counties. In the 1980s, Los Angeles County experienced sharp real estate appreciation. As ozone levels in San Bernardino and Riverside fall, these suburban counties are closer substitutes for Los Angeles County living and there may be a cross-elasticity effect. To study the "push" effect

[5]For research on the conversion of farmland for urban use see Fischel (1982), Westerby and Heimlich (1991).

[6]To proxy for county human capital levels, I have included in the regressions the share of the county's adults in 1980 who are college graduates. Unfortunately, the correlation between this variable and median home prices is 0.85. Thus, I do not report results with the two variables in the same specification.

TABLE 2: Explaining California County Population Growth 1980 to 1994

The dependent variable is county population growth between 1980 to 1994.
The two regressions are based on Equation (2) in the text.

	Beta (Standard Error)	Beta (Standard Error)	Mean (Standard Error)
Change in High Ozone days between 1980 and 1994	–.0078 (.0021)		–4.115 (10.66)
San Bernardino and Riverside County Dummy		.484 (.115)	.0344 (.184)
Farmland	.260 (.095)	.234 (.089)	.378 (.262)
Percentage of Population Hispanic, 1980	.0039 (.0023)	.0051 (.0021)	13.11 (10.70)
1980–1985 Local Labor Demand	27.16 (6.064)	25.23 (5.885)	.0969 (.0051)
Median County Home Price 1980 ($1,000s)	–.0062 (.0013)	–.0053 (.0012)	71.96 (22.11)
Constant	–1.983 (.549)	–1.854 (.532)	
Observations	58	58	
R^2	.47	.51	

Note: Data sources are the Bureau of Economic Analysis's REIS CD-ROM and the 1988 City and County Fact Book. 1980–1985 local labor market demand variable is defined in the text. It is proxied for using national employment growth in 15 industries weighted by the county's share of employment in each of these industries in 1980. Farmland is the percentage of the county's area that is farmland. High ozone days is measured as the count of days where at least one monitoring station in the county exceeded the national 1-hour standard.

of high nearby home prices, for each county I constructed the average price of homes in 1979 in adjacent counties. Although the correlation between this variable and the own county median home price is 0.72, I find that adjacent county home prices are statistically insignificant and own-county home prices continue to be negatively correlated with county population growth.

The results in Table 2 suggest that counties where ozone levels fell experienced increased population growth. Riverside and San Bernardino experienced sharp population growth between 1980 and 1994 even relative to nearby "control group" counties such as Kern or Ventura. In the next section I document ozone trends to show that the greatest air quality improvements in California took place in Riverside and San Bernardino.

3. CALIFORNIA COUNTY OZONE TRENDS, 1980–1996

An important factor making Riverside and San Bernardino more attractive places to live is falling ozone smog. Good air quality and time spent outdoors are likely to be complements. As ozone levels fall people can spend more time outdoors without sacrificing good health (Bresnahan, Dickie, and Gerking, 1997). The Los Angeles region has had the worst ozone smog levels in the nation. Ground level ozone is one the six "criteria" pollutants regulated by the Environmental Protection Agency under the National Ambient Air Quality Standards (NAAQS).[7] Many parts of the Los Angeles region have had awful ozone problems such that ozone exceeded the Clean Air Act standards on over half of all days in the 1970s. In 1977, ozone exceeded 0.2 parts per million on 121 days at at least one monitoring station in the Los Angeles region. The Los Angeles area is the only area in the country that the Environmental Protection Agency has assigned to extreme nonattainment. Regulation has been successful at reducing ozone. Despite population growth of 32.4 percent in the Los Angeles region between 1980 and 1994 and even greater vehicle mileage growth, the number of days that ozone exceeded 0.2 parts per million dropped to only 7 in 1996.[8]

The regulation's benefits have been spatially concentrated. Locations farther from the water and closer to the San Gabriel mountains and San Bernardino and Riverside counties have experienced sharper absolute reductions in pollution. While other parts of California such as San Diego, Ventura, and Fresno featured high ozone levels and have also enjoyed improvements, no other parts of the state have experienced such gains. People who live in the Los Angeles region have faced the same regulatory costs as other Californians but have received disproportionately higher benefits.[9]

To document ambient ozone pollution trends, I use the California EPA's Air Resources Board's California Ambient Air Quality Data 1980–1996. In Table 3 I present ozone trends within the Los Angeles metropolitan region (defined as Los Angeles, Orange, Riverside and San Bernardino, Kern, San Diego, and Ventura counties) versus all other counties in California. I present average smog trends for 1980–1984, 1985–1989, and 1990–1996 for six different measures of ozone smog. In areas outside the Los Angeles region, the average number of annual exceedences of the national one-hour ozone standard was 3.084 in the early 1980s and this fell to 0.983 in the 1990s. This absolute drop of 2 high ozone days per year is dwarfed by the pollution gains in the Los Angeles region where the count of exceedence days fell by 27. The table shows that ozone levels have fallen monotonically across all six measures with the greatest reductions taking place within the Los Angeles area.

Table 3 documents that the ozone declines are concentrated in the southern part of the state. To pinpoint where the greatest gains have been achieved within this geographic area, Table 4 presents means for the six ozone measures for two time periods. The Los Angeles region is partitioned into (1) Los Angeles County, (2) Riverside and San Bernardino counties, and (3) Orange, San Diego, Kern,

[7]For a more detailed discussion of the Clean Air Act see Portney (1991).

[8]Daily Los Angeles ozone readings are available at *www.aqmd.gov/smog*.

[9]All California motorists face the same new car standards and used vehicles have been subject to an emissions testing program featuring very high pass probabilities and low fines for those vehicles that do fail (Kahn 1996b).

TABLE 3: California Ozone Trends Inside and Outside Los Angeles

	The Greater Los Angeles Area			California but not the Greater Los Angeles Area		
Ozone Standard	1980–1984	1985–1989	1990+	1980–1984	1985–1989	1990+
Count of Days Exceeding National 1 Hour	47.611	39.750	20.275	3.084	1.886	0.983
	(44.257)	(41.553)	(27.440)	(10.589)	(4.596)	(4.187)
Count of Days Exceeding State 1 Hour	82.453	79.193	52.681	13.032	12.823	8.987
	(52.673)	(54.009)	(43.590)	(19.975)	(19.385)	(14.863)
Count of Days Exceeding National 8 Hour	61.558	59.017	37.559	8.720	8.903	6.588
	(46.274)	(45.651)	(35.901)	(16.947)	(16.272)	(13.105)
Maximum 1 Hour Reading	0.239	0.210	0.167	0.121	0.119	0.108
	(0.081)	(0.065)	(0.050)	(0.040)	(0.033)	(0.026)
Maximum 8 Hour Reading	0.167	0.153	0.126	0.094	0.095	0.088
	(0.051)	(0.044)	(0.032)	(0.028)	(0.023)	(0.019)
Mean of Top 30 Annual 1 Hour Readings	0.166	0.149	0.124	0.085	0.085	0.081
	(0.062)	(0.049)	(0.036)	(0.029)	(0.023)	(0.020)
Observations	285	300	454	439	464	866

Note: This table presents means by cell. Standard deviations are presented in parentheses. The data source is the California EPA's Air Resources Board's California Ambient Air Quality Data 1980–1996. The Greater Los Angeles Area is defined as the following counties: Orange, Los Angeles, San Bernardino, Riverside, San Diego, Kern and Ventura. The unit of analysis is an ambient monitoring station.

and Ventura counties. Although the latter group has an ozone problem and has experienced improved air quality, these gains are small relative to the gains for the first two groups. Riverside and San Bernardino has very high pollution, which was even worse in the 1970s. This area has also experienced the sharpest absolute reduction in smog. The average resident has experienced a reduction in national exceedence days of over 35. Residents of Los Angeles County have also been exposed to much less smog pollution with mean exposure to high ozone days falling from 65.2 in the early 1980s to 29.3 in the 1990s.

4. OTHER POTENTIAL EXPLANATIONS FOR IMPROVED QUALITY OF LIFE IN THE LOS ANGELES SUBURBS

The county population growth regressions presented in Table 2 focused on economic variables such as home prices, immigrants, and labor demand. Although air pollution reduction's correlation with local growth was documented, it is possible that there are other local public goods which encourage growth. For example, the Los Angeles fringe might grow if crime levels fell. Using the variable "crimes known to the FBI per-capita," I have studied trends in California crime between 1980 and 1991. In results that are available on request, I find no evidence of differential crime reductions in the Los Angeles suburbs relative to the rest of the counties in the state.

TABLE 4: Ozone Trends Within the Los Angeles Region

Ozone Standard	County					
	Los Angeles		Riverside and San Bernardino		San Diego, Kern, Ventura, Orange	
	1980–1984	1990+	1980–1984	1990+	1980–1984	1990+
Count of Days Exceeding National 1 Hour	65.207	29.294	70.517	33.784	17.070	5.137
	(40.237)	(29.199)	(49.133)	(32.554)	(17.415)	(7.890)
Count of Days Exceeding State 1 Hour	101.061	63.606	107.303	74.128	49.667	30.523
	(48.165)	(43.334)	(55.788)	(47.686)	(32.620)	(27.278)
Count of Days Exceeding National 8 Hour	71.037	37.716	89.090	57.723	33.246	22.325
	(42.782)	(32.193)	(48.469)	(40.668)	(27.738)	(25.043)
Maximum 1 Hour Reading	0.285	0.187	0.253	0.187	0.194	0.142
	(0.072)	(0.053)	(0.087)	(0.055)	(0.056)	(0.030)
Maximum 8 Hour Reading	0.190	0.132	0.184	0.142	0.138	0.110
	(0.049)	(0.035)	(0.058)	(0.035)	(0.029)	(0.018)
Mean of Top 30 Annual 1 Hour Readings	0.196	0.137	0.189	0.139	0.127	0.105
	(0.059)	(0.040)	(0.067)	(0.038)	(0.030)	(0.018)
Observations	82	109	89	148	114	197

Note: This table presents means by cell. Standard deviations are presented in parentheses. The data source is the California EPA's Air Resources Board's California Ambient Air Quality Data 1980–1996. The unit of analysis is an ambient monitoring station.

Congestion is a growing disamenity in many metropolitan areas (see Downs, 1991). Los Angeles has many employment sub-centers away from its CBD (Giuliano and Small, 1991).[10] More households may be seeking out suburban locations closer to their work. Gordon, Kumar, and Richardson (1991) document that commuting times have decreased as suburban sprawl has continued. One testable hypothesis is that the Los Angeles suburbs offer shorter commuting times for residents. In this case, we might expect to see new migrants to the area having shorter commutes than existing residents. Using the 1990 Census

[10]Los Angeles does not feature a single central business district and employment is decentralizing (Giuliano and Small, 1991). San Bernardino's population growth between 1969 and 1992 is much greater than its employment growth (75 percent to 42 percent). Increased highway expenditure and the development of I-10 and I-15 have stimulated trucking and warehousing employment in San Bernardino. Between 1970 and 1990, Los Angeles County's total employment grew at an annual rate of 2.23 percent while in the suburban counties the growth rate was 4.87 percent with services growing by 6.74 percent a year (McDonald, 1997).

IPUMS micro data (Ruggles and Sobek, 1997), I calculate average worker one-way commute to work for all workers in each of 23 California metropolitan areas. These results are listed in Table 5. The commutes of San Bernardino workers have not fallen sharply between 1980 and 1990. In fact, San Bernardino's workers have the longest average commutes of any workers across California's metropolitan areas. These long commutes reflect the fact that over 45 percent of San Bernardino's residents work in Los Angeles County. The results in Table 5 indicate that the average new migrant to the San Bernardino area who lived outside the metropolitan area in 1985 has a 35.4 minute one-way commute (the longest of any commuters in California) whereas the average San Bernardino worker who did not switch homes between 1985 and 1990 had a 28.4 minute commute. This seven-minute differential is statistically significant and suggests that new migrants are not locating closer to their employment than nonmigrants.

TABLE 5: 1990 Cross–Metro Area Variation in One-Way Commute Times Measured in Minutes

MSA	Average Commuting Time (in Minutes) for Heads of Households who did not Change Homes Between 1985 and 1990	Average Commuting Time for Workers who Switched Homes Between 1985 and 1990 (in Minutes)	Average Commuting Time for Workers who Switched Metro Areas Between 1985 and 1990 (in Minutes)
Bakersfield	19.763	20.197	23.254***
Chico	18.293	17.533	17.034
Fresno	20.372	18.886	19.836
Los Angeles	27.102	27.779***	27.094*
Anaheim	27.856	26.041***	27.860***
Merced	15.151	13.776	21.820***
Modesto	19.537	21.502	31.125***
Redding	16.714	15.904	19.422
San Bernardino	28.421	28.449	35.464***
Sacramento	23.151	22.907	22.130
Salinas	17.895	17.314	16.780
San Diego	24.171	22.836***	23.162
San Francisco	26.655	26.412	25.433
Oakland	28.242	27.870	30.610***
Napa	26.150	26.798	31.188
San Jose	25.390	24.648	21.694***
Santa Barbara	18.653	21.232*	18.123**
Santa Cruz	29.126	23.573**	24.766
Santa Rosa	25.584	24.591	30.557***
Stockton	23.195	18.478***	30.860***
Ventura	28.799	26.107**	30.744***
Visalia	16.739	17.258	20.729*
Yuba City	21.661	19.915	22.057

Note: To signify whether commuting times are statistically significantly different than nonmovers' commute times *** indicates the 1 percent level, ** the 5 percent level and * at the 10 percent level. The sample includes all heads of households. The data source is the 1990 IPUMS.

5. MIGRATION TRENDS AND HOME PRICE CHANGES IN THE LOS ANGELES SUBURBS

Population growth regressions do not distinguish who is entering the county at a point in time. An important hypothesis to test is whether Riverside and San Bernardino are now increasingly attracting residents who place a high value on local quality of life relative to the migrants these regions used to attract. To document recent trends in the locational choice of new migrants to the Los Angeles region, I study where the retired and college graduates are locating. If ozone is an important quality of life component then as ozone declines previously high ozone areas will attract people who in the past would not have chosen to live there. Suggestive evidence of improved quality of life is if the retired and the college educated are increasingly likely to locate in these polluted counties. The quality-of-life literature has documented that amenities such as climate, low pollution, and safety are normal goods and that the retired seek out amenity-rich areas (Graves and Waldman, 1991; Evans, 1980).

To quantify changes in the propensity to move to Riverside or San Bernardino (the San Bernardino metropolitan area) versus Anaheim and Los Angeles, I pool 1980 and 1990 IPUMS census data (Ruggles and Sobel, 1997) to estimate a locational choice model. For people who lived outside the Los Angeles region in the base year (1975 for the 1980 data, 1985 for the 1990 data) who moved to the Los Angeles region, I estimate the probability that one chooses to move to the Anaheim, Los Angeles, or the San Bernardino SMSA as a function of whether a head of household is nonwhite, education, and age. Table 6 presents the coefficient estimates from a mulitnomial logit.[11] A 1990 calendar-year dummy is included as well as interactions of the 1990 dummy with the demographic variables.

Table 7 presents the predicted probabilities based on the MNL estimates. The top row of Table 7 reports the raw shares of where new migrants located in 1980 and 1990. Los Angeles received 68.6 percent of the new migrants in 1980 and 65.95 percent in 1990. San Bernardino's share increased from 13.8 percent to 16.69 percent. The next two rows of the table report predicted probabilities holding all other personal attributes at their sample means. College graduates have sharply increased their propensity to move to San Bernardino. In 1980 only 7.3 percent of this group moved there but by 1990, 11.9 percent moved to San Bernardino. Household heads aged 70 have also

[11]An alternative approach would be to estimate a mixed logit model to include attributes of the choice variables (the three metropolitan areas). Concern about mispecification of the correct set of local public goods and difficulities in collecting such relevant data as local crime levels, distance from the beach, and local school quality force me to focus on how the predicted probability of choosing each area has changed over time without specifying the relative importance of location specific attributes in causing the increased migration propensities. Although this approach cannot prove that ozone reductions "cause" increased growth, this multinomial logit approach does show that there is a statistically significant change in the impact of demographics on locational choice which must be linked either to economic opportunity or changes in local public goods.

TABLE 6: 1980 and 1990 Los Angeles CMSA Migrant Destination Multinomial Logit Estimates

The discrete choice is to move to either: Anaheim, Los Angeles or San Bernardino.

	Beta	Standard Error	Z
Probability Choose Anaheim			
Nonwhite Dummy	−2.2451	0.0093	−241.3340
1990 Dummy	−0.1344	0.0204	−6.5970
College Graduate Dummy	0.2101	0.0039	53.8070
Age	0.0113	0.0006	17.8270
Age Squared	−0.0001	0.0000	−22.4380
College × 1990 Year Dummy	0.0690	0.0053	13.0720
Age × 1990 Year Dummy	0.0039	0.0009	4.4900
Age^2 × 1990 Year Dummy	−0.0000	0.0000	−1.5070
Constant	−1.4920	0.0141	−105.8040
Probability Choose San Bernardino			
Nonwhite Dummy	−0.9504	0.0054	−174.4410
1990 Dummy	−0.1326	0.0205	−6.4640
College Graduate Dummy	−0.3978	0.0049	−81.4750
Age	−0.0219	0.0006	−34.2640
Age^2	0.0003	0.0000	42.0690
College × 1990 Year Dummy	−0.0484	0.0064	−7.5460
Age × 1990 Year Dummy	0.0213	0.0009	24.6550
Age^2 × 1990 Year Dummy	−0.0003	0.0000	−30.7010
Constant	−1.0661	0.0146	−73.1140

Note: The sample includes all heads of households who live in the greater Los Angeles area in either 1980 or 1990 but did not live in the CMSA five years before. The omitted category is a nonblack head of household in 1980 who is not a college graduate. Los Angeles is the omitted choice category. The Pseudo R^2 for the multinomial logit model is 0.02 and there were 50,902 observations in the estimation.

increased their propensity to migrate to the San Bernardino metropolitan area, from 15 percent to 16.82 percent between 1980 and 1990. Not only is San Bernardino increasingly attracting retirees and more-educated people but it is also attracting intra–Los Angeles region migrants. For households who lived in the Los Angeles region in 1985, the population is more likely to move from Anaheim to San Bernardino than vice versa. Between 1985 and 1990 6.3 percent of Anaheim's population moved to San Bernardino by 1990 while only 1.7 percent of San Bernardino's 1985 stock moved to Anaheim. In 1990, 37.3 percent of the migrants to San Bernardino lived in Los Angeles county five years previously.

Increased migration to the San Bernardino area would drive up home prices and discourage further in-migration to the area if housing supply were inelastic. In this case, incumbent land owners would experience a windfall (Pollinsky and Shavell, 1975; Ackerman, 1979; Pines and Weiss, 1979). The special feature of

TABLE 7: Predicted Migration Rates for New Entrants to the Los Angeles Region in 1980 and 1990

Demographic Group	Destination: Anaheim		Los Angeles		San Bernardino	
	1980	1990	1980	1990	1980	1990
Actual	17.54	17.36	68.61	65.95	13.85	16.69
Predicted Based on MNL						
College Graduate	20.11	20.95	72.50	67.21	7.30	11.90
Age Equals 70	15.82	15.79	69.18	67.39	15.00	16.82

Note: In 1980 and 1990 new migrants to the Los Angeles region choose whether to locate in Anaheim, Los Angeles, or San Bernardino. This table reports actual and predicted migrant shares to each metropolitan area. In each decade, the shares sum to 100. The predicted probabilities are based on the coefficient estimates reported in Table 6 holding all other explanatory variables at their sample means.

suburban locations is undeveloped land. Fringe farm land can be converted into suburbia and is likely to be converted when the opportunity cost of farmland is high (Brueckner and Fensler, 1982). The ozone improvements concentrated in the San Bernardino area offer an interesting test case for exploring trends in capitalization. Who bears the incidence from a regulation-induced improvement in local quality of life?

To study trends in home prices, I use three cross-sections of the American Housing Survey (AHS) from 1986, 1991, and 1994 to estimate hedonic real estate price regressions. These three waves of the AHS include subsamples of the Anaheim and San Bernardino metropolitan areas. Under the assumption that both of these areas offer access to the greater Los Angeles labor market, it is of interest to study relative price changes. The left two columns of Table 8 report a log home-price hedonic and the right two columns report a log rental hedonic. Controlling for a battery of housing controls, I focus on the San Bernardino fixed effect relative to the Anaheim fixed effect. San Bernardino homes are 48 percent cheaper in 1986 relative to the same home if it were in Anaheim. The regression results indicate that quality-adjusted San Bernardino homes have actually fallen in price relative to their Anaheim counterparts. New suburban construction may have increased supply by more than demand has increased. Although there is ongoing concern about the social costs of suburban sprawl, one private benefit is that it allows more households to access affordable suburban housing. San Bernardino renters have enjoyed a sharp reduction in ozone exposure without having to pay higher rents. New suburbanites are able to purchase relatively low price new housing in this area.

TABLE 8: Anaheim and San Bernardino Hedonic Housing Price Regressions

	Dependent Variable			
Explanatory Variables	log(*home price*)		log(*rent*)	
	beta		beta	
San Bernardino Dummy Interacted With 1990 Dummy	−0.050	0.025	0.066	0.019
San Bernardino Dummy Interacted With 1994 Dummy	−0.115	0.024	0.063	0.019
San Bernardino Dummy	−0.499	0.018	−0.478	0.014
1990 Dummy	0.172	0.019	0.013	0.012
1994 Dummy	−0.002	0.018	−0.082	0.012
Unit is Single Detached	0.679	0.015	0.043	0.012
Unit Square Footage (1000s)	0.269	0.014	0.099	0.013
Dummy for Missing Data for Unit Square Footage	0.402	0.025	0.052	0.015
Rooms	0.052	0.005	0.065	0.004
Bathrooms	0.065	0.010	0.118	0.009
Lot Size (1000s)	0.003	0.000		
Dummy for Missing Lot Size	0.144	0.012		
Garage Dummy	0.324	0.022	0.119	0.010
Constant	10.366	0.044	8.709	0.029
Observations	9753		8240	
R^2	.49		.47	

Note: The data source is the 1986, 1990 and 1994 waves of the American Housing Survey. The sample includes all units which are not rent controlled or public housing. The units are 1994 dollars. Year-built dummies are included in the regressions. The omitted category is a 1986 Anaheim attached unit with no garage.

6. CONCLUSION

Quality of life is an important determinant of household location patterns. If a location's quality of life improves it may experience population growth and increasingly attract migrants who chose not to live there in the past. In this paper I argue that high ozone levels in the Los Angeles suburbs have played a role in discouraging growth in the area. As Clean Air Act regulation reduced smog problems the Los Angeles suburban counties became increasingly attractive places to live. Cheap land and access to higher quality of life have encouraged in migration.

The pursuit of high quality cheap housing and the pursuit of low ozone levels are not mutually exclusive. Urban researchers have documented that suburban living is a normal good (Margo, 1992; Mieskowski and Mills, 1993; Wheaton, 1977). Land and ozone are likely to be complements. As ozone levels fall, spending time outdoors becomes a more enjoyable activity and people will have a greater demand for land to play sports on or to have a swimming pool (Bresnahan, Dickie, and Gerking, 1997).

The results in this paper should not be interpreted to mean that reduced smog can cause any county to grow. The Los Angeles suburbs represent a special case because the Greater Los Angeles area offers access to a diverse local labor market and a highly demanded climate and lifestyle. Reduced smog allows residents to access this lifestyle at a lower cost than in Anaheim or Los Angeles

County. Smog's presence may have been holding back development. As smog levels have fallen the demand for living in this area has increased. Future research might explore whether an unintended consequence of Clean Air Act regulation is to encourage economic development in highly polluted areas.[12]

REFERENCES

Ackerman Rose, Susan. 1977. "On the Distribution of Public Program Benefits Between Landlords and Tenants," *Journal of Environmental Economics and Management,* 5, 167–184.

Bartik, Timothy. 1991. *Who Benefits from State and Local Economic Development Policies?* Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

Becker, Randy and Vernon Henderson. 1997. "Effects of Air Quality Regulation on Decisions of Firms in Polluting Industries," NBER Working Paper No. 6160.

Berger, Mark C., and Glenn C. Blomquist. 1992. "Mobility and Destination in Migration Decisions: The Roles of Earnings, Quality of Life, and Housing Prices," *Journal of Housing Economics,* 2, 37–59.

Berman, Eli and Linda Bui. 2000. "Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin," *Journal of Public Economics.*

Blanchard, Olivier Jean and Lawrence F. Katz. 1992. "Regional Evolutions," *Brookings Papers on Economic Activity,* 1, 1–75.

Blomquist, Glenn. 1991. "Motorist Use of Safety Equipment: Expected Benefits or Risk Incompetence," *Journal of Risk and Uncertainty,* 4, 135–152.

Bound, John and Harry Holzer. 1996. "Demand Shifts, Population Adjustments and Labor Market Outcomes: 1980–1990," NBER Working Paper No. 5685.

Bresnahan, Brian, Mark Dickie, and Shelby Gerking. 1997. "Averting Behavior and Urban Air Pollution," *Land Economics,* 73, 340–357.

Brookshire, David S., Ralph C. d'Arge, William D. Schulze, and Mark A. Thayer. 1982. "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches," *American Economic Review,* 72, 165–177.

Brueckner, Jan and David Fansler. 1983 "The Economics of Urban Sprawl: Theory and Evidence on the Spatial Sizes of Cities," *Review of Economics and Statistics,* 65, 479–482.

California Environmental Protection Agency, Air Resources Board. California Ambient Air Quality Data 1980–1996. Www.aqdcd.org.

Chirinko, Robert and Edward P. Harper. 1993. "Buckle Up or Slow Down? New Estimates of Offsetting Behavior and Their Implications for Automobile Safety Regulation," *Journal of Policy Analysis and Management,* 12, 270–296.

Crandall, Robert and John Graham. 1984 "Automobile Safety Regulation and Offsetting Behavior: Some New Empirical Estimates," *American Economic Review,* 74, 328–331.

Dickie, Mark and Shelby Gerking. 1991. "Willingness to Pay for Ozone Control: Inferences from the Demand for Medical Care," *Journal of Environmental Economics and Management,* 21, 1–16.

———. 1997. "Genetic Risk Factors and Offsetting Behavior: The Case of Skin Cancer," *Journal of Risk and Uncertainty,* 15, 81–97.

DiPasquale, Denise and Matthew Kahn. 1999. "Measuring Neighborhood Investment: Evidence from Migrant Locational Choice," *Real Estate Economics,* 27, 389–424.

[12]A growing empirical literature has documented the displacement effects induced by differential regulation. Environmental, safety, and product regulation have been shown to induce offsetting behavior (Peltzman, 1975; Dickie and Gerking, 1997; Blomquist, 1991; Evans and Graham, 1991; Keeler, 1994; Chirinko and Harper, 1993; Viscusi, 1984; Viscusi and Cavallo, 1994; Peterson, Hoffer, and Milner, 1995; Crandall and Graham, 1984; Godek, 1997). Differential regulation of new vehicle and manufacturing capital has encouraged both car owners and firms to substitute toward keeping older less regulated capital longer than they would have had newer capital faced less stringent regulation (Gruenspecht, 1982; Nelson, Tietenburg, and Donihue, 1993).

Dowall, David. 1984. *The Suburban Squeeze*. Berkeley: University of California Press.
Downs, Anthony. 1991. *Stuck in Traffic*. Washington, DC: The Brookings Institution.
Evans, Alan W. 1980. "The Assumption of Equilibrium in the Analysis of Migration and Interregional Differences: A Review of Some Recent Research," *Journal of Regional Science*, 30, 515–531.
Evans, William and John Graham. 1991. "Risk Reduction or Risk Compensation? The Case of Mandatory Seat-Belt Use Laws," *Journal of Risk and Uncertainty*, 4, 61–74.
Fischel, William. 1982. "The Urbanization of Agricultural Land: A Review of the National Agricultural Lands Study," *Land Economics*, 58, 236–259.
———. 1990. *Do Growth Controls Matter?* Cambridge MA: Lincoln Institute of Land Policy.
———. 1995. *Regulatory Takings: Law, Economics and Politics.* Cambridge, MA: Harvard University Press.
Gabriel, Stuart, Janice Marquez, and William Wascher. 1992. "Regional House Price Dispersion and Interregional Migration," *Journal of Housing Economics*, 2, 235–256.
Giuliano, Genevieve and Kenneth Small. 1991. "Subcenters in the Los Angeles Region," *Regional Science and Urban Economics*, 21, 163–182.
Godek, Paul. 1997. "The Regulation of Fuel Economy and the Demand for 'Light Trucks'," *Journal of Law and Economics*, 40, 495–509.
Gordon, Peter, Ajay Kumar, and Harry Richardson. 1991. "The Influence of Metropolitan Spatial Structure on Commuting Time," *Journal of Urban Economics*, 26, 138–151.
Grant, Wyn. 1995. *Autos, Smog and Pollution Control*. Aldershot, U.K.: Edward Elgar.
Graves, Philip E. and Donald M. Waldman. 1991. "Multimarket Amenity Compensation and the Behavior of the Elderly," *American Economic Review*, 81, 1374–1381.
Gray, Wayne. 1987. "Manufacturing Plant Location: Does State Pollution Regulation Matter?" NBER Working Paper No. 5880.
Gruenspecht, Howard. 1982 "Differentiated Regulation: The Case of Auto Emissions Standards," *American Economic Review*, 2, 329–332.
Hall, Jane et al. 1992. "Valuing the Health Benefits of Clean Air," *Science*, February 14, 812–816.
Henderson, Vernon. 1996. "The Effect of Air Quality Regulation," *American Economic Review*, 86, 789–813.
Hoehn, John P., Mark C. Berger, and Glenn C. Blomquist. 1987. "A Hedonic Model of Interregional Wages, Rents, and Amenity Values," *Journal of Regional Science*, 27, 605–620.
Kahn, Matthew. 1996a. "New Evidence on Trends in Vehicle Emissions," *Rand Journal of Economics*, 27, 183–196.
———. 1996b. "The Efficiency and Equity of Vehicle Emissions Regulation: Evidence from California's Random Audits," *Eastern Economic Journal*, Fall, 457–466.
———. 1997. "Particulate Pollution Trends in the United States," *Regional Science and Urban Economics*, 27, 87–107.
Katz, Lawrence and Kenneth Rosen, 1987. "The Interjurisdictional Effects of Growth Controls on Housing Prices," *Journal of Law and Economics*, 30, 149–160.
Keeler, Theodore. 1994. "Highway Safety, Economic Behavior and Driving Environment," *American Economic Review*, 84, 684–693.
Landis, John. 1992. "Do Growth Controls Work? A New Assessment," *Journal of American Planning Association*, 58, 489–506.
Lazzareschi, Carla. 1989. "Fontana Shedding Its Steel Town Image," *Los Angeles Times*, August 6, Section 8, p. 2.
Levinson, Arik. 1996. "Environmental Regulations and Manufacturers' Location Choices: Evidence from the Census of Manufactures," *Journal of Public Economics*, 62, 5–29.
Margo, Robert. 1992. "Explaining the Postwar Suburbanization of the Population in the United States: The Role of Income," *Journal of Urban Economics*, 31, 301–310.
Mieskowski, Peter and Edwin Mills. 1993. "The Causes of Metropolitan Suburbanization," *Journal of Economic Perspectives*, 7, 135–147.
McDonald, John. 1997. *Fundamentals of Urban Economics*. Englewood Cliffs: Prentice Hall.

National Research Council. 1991. *Rethinking the Ozone Problem in Urban and Regional Air Pollution*. Washington, DC: National Academy Press.

Nelson, Randy A., Tom Tietenberg, and Michael Donihue. 1993. "Differential Environmental Regulation: Effects on Electric Utility Capital Turnover and Emissions," *Review of Economics and Statistics*, 75, 368–373.

Peltzman, Sam. 1975. "The Effects of Automobile Safety Regulation," *Journal of Political Economy*, 83, 677–725.

Peterson, Steven, George Hoffer, and Edward Milner. 1995. "Are Drivers of Air-Bag Equipped Cars More Aggressive? A Test of the Offsetting Behavior Hypothesis," *Journal of Law and Economics*, 38, 251–264.

Pines, David and Yoram Weiss. 1976."Land Improvement Projects and Land Values," *Journal of Urban Economics*, 3, 1–13.

Polinsky, A. Michael and Steven Shavell. 1975. "The Air Pollution and Property Value Debate," *Review of Economics and Statistics*, 57, 100–104.

Porrell, Frank. 1982. "Intermetropolitan Migration and Quality of Life," *Journal of Regional Science*, 22, 137–158.

Portney, Paul. 1990. "Air Pollution Policy," in P. Portney (ed.), *Public Policies for Environmental Protection*, Washington, DC: Resources for the Future.

Ruggles, Steven and Matthew Sobek. 1997. Integrated Public Use Microdata Series: Version 2.0 Minneapolis: Historical Census Projects, University of Minnesota. http://www.ipums.umn.edu.

Viscusi, Kip. 1984. *Regulating Consumer Product Safety*. Washington, DC: American Enterprise Institute.

Viscusi, Kip and Gerald Cavallo. 1994. "The Effect of Product Safety Regulation on Safety Precautions," *Risk Analysis*, 14, 917–929.

Westerby, Marlow and Ralph Heimlich. 1991. " Land Use and Demographic Changes: Results from Fast Growth Counties," *Land Economics*, 67, 279–291.

Wheaton, William. 1977. "Income and Urban Residence: An Analysis of Consumer Demand for Location," *American Economic Review*, 67, 620–634.