The Long-Run Impact of Air Pollution on Life Expectancy: Evidence from China's Huai River Policy

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Abstract: This study exploits an arbitrary Chinese law to provide the first evidence on the impact of sustained exposure to total suspended particulates (TSP) air pollution on life expectancy. During the 1950-1980 central planning period, China established free winter heating of homes and offices via the provision of free coal for boilers in cities North of the Huai River as a basic right and largely denied heat to the South. Using a regression discontinuity design based on distance from the Huai River, we find that in cities to the North ambient concentrations of TSPs are about 200 μg/m^3 (55%) higher and life expectancies are about 5 years lower. Moreover, the premature mortality is due to an increased prevalence of lung-related causes of death. We estimate that long-term exposure to an additional 100 μg/m^3 of TSP is associated with a reduction in life expectancy at birth of about 2.5 years. This estimate is roughly 5 times larger than the estimated impact of TSPs on life expectancy from the fitting of an ordinary least squares equation.

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I. Introduction

Air quality in China is notoriously poor. Ambient concentrations of total suspended articulates (TSP) between 1981-2001 were more than double China's National Annual Mean Ambient Air Quality Standard of 200 μg/m^3 (1) and five times the level that prevailed in the US level before the passage of the Clean Air Act in 1970. Furthermore, air quality is especially poor in Northern Chinese cites, which is home to several of the world's most polluted cities (2). Following a career in the Southern China city of Shanghai, Prime Minister Zhu Rongi reportedly quipped in 1999: "If I work in your Beijing [a North China city], I would shorten my life at least five years" (3).

This paper examines the health consequences of these extraordinary pollution levels by exploiting a seemingly arbitrary Chinese policy that produced dramatic differences in air quality within China. During the 1950-1980 period of central planning, the Chinese government established free winter heating of homes and offices via the provision of free coal for fuel boilers as a basic right. The combustion of coal in boilers is associated with the release of air pollutants, and in particular, emission of particulate matter that can be extremely harmful to human health (4-5). Due to budgetary limitations, however, this right was only extended to areas located in North China, which is defined by the line formed by the Huai River and Qinling Mountain range (see Figure 1). As we will document, total suspended particulate (TSP) levels in cities north of the line are significantly higher than in cities south of the line, and this difference persisted for several decades.

The study has several compelling features. First, we are able to estimate the impact of long run exposure to TSP on life expectancy. As we will document, the policy caused long-run differences in TSP concentrations between cities North and South of the Huai River. Further, during the period in question, the *hukou* (household registrations) system restricted mobility so in general individuals will be observed where they lived most of their lives. In contrast, studies that use US and other developed country data must assume no migration, which is undermined by the high rates of migration in the US and the potential selection of location based on air pollution concentrations, or assume that short-run variation in air pollution is informative about life expectancy (6-7). Second, the availability of the regression discontinuity design based on the Huai River policy provides an appealing quasi-experimental approach that is likely to solve the confounding that has plagued much of the previous literature. Third, China's air is extremely polluted and we are unaware of any previous evidence on this relationship at these concentrations. Fourth, the analysis is conducted with a new and unique data file that contains city-level information on air pollution, weather, determinants of mortality, and age- and cause-specific mortality rates from a panel of 90 Chinese cities from 1991-2000.

II. Data Sources

The data set for this analysis was compiled from several sources. China's problems with air pollution in the 1970s encouraged policymakers to establish monitoring stations throughout the country. We collected information on annual daily average concentrations of TSP for 90 cities from 1981 to 2000. These data were compiled through a combination of hand entry from Chinese language publications, and in more recent years, access to electronic files (8). During this period, we also have access to daily average temperature data for each city in the air pollution sample. These data were obtained from the World Meteorological Organization (9). We also collected a series of control variables from the 2000 Census, including the average age of the population, the share working in manufacturing, and the fraction of the population in four different income categories.

The mortality data are derived from China's Disease Surveillance Points (DSP) system

(10). The DSP is a set of 145 sites chosen to be nationally representative (benchmarked against the 1990 China census) so that it captures China's variation in wealth, urbanicity, and geographic dispersion. The DSP records all deaths and population counts at the sites and yields a nationally representative annual sample of deaths (11). The analysis will rely on the data taken from roughly 500,000 deaths recorded at sites between 1991 and 2000, and population counts by age and sex that are used to convert the recorded deaths into city-level mortality rates for ages 1, 5, 10, and 5 year increments through age 80. Additionally, these mortality rates are used to calculate an overall mortality rate based on China's age distribution in 2000 and the life expectancy, both measured at the city by year level.

Importantly, the cause of death is also recorded after multiple validation checks. We classify causes of death as either being lung related or non-lung related. The lung related causes of death that are those that have been linked to ambient air quality and include heart disease (12), stroke (13-15), lung cancer (16), and respiratory illnesses (17-18). Causes of death presumably unrelated to air quality include other cancers, accidental or violent deaths, and various stomach ailments. Together, these two categories cover all causes of death.

To estimate the impact of long-run exposure to pollution, the city-level panel data is collapsed to a 125 observation city-level cross-sectional data set. This is accomplished by averaging the annual city-level measures of mortality rates, life expectancies, pollution concentrations, weather variables and other covariates. Additionally, we used GIS to identify the degrees latitude that each city centroid is north of the Huai River line and merged this information into the final data set. The supplementary online materials provide more details on the procedure used to collapse the data file and the data sources.

III. Econometric Model

We use two approaches to estimate the relationship between TSP and human health. The first approach is a “conventional” strategy that uses ordinary least squares to fit the following equation to the cross-sectional data file:

$$Y_j = \beta_0 + \beta_1 TSP_j + X_j \Gamma + \varepsilon_j \qquad (1)$$

where TSP_j is the total suspended particulates concentration in city j calculated with the 1981-2000 TSP data, X_j is a vector of the observable characteristics of the city that might influence health outcomes other than air quality, and ε_j is a disturbance term. The dependent variable is Y_j, which is either a measure of mortality rates in city j or its residents' life expectancy (which is a simple function of mortality rates).

The coefficient β_1 measures the effect of TSP exposure on mortality, after controlling for the available covariates. Consistent estimation of β_1 requires that unobserved determinants of mortality do not covary with TSP_j (after adjustment for TSP_j). This “conventional” approach rests on the assumption that linear adjustment for the limited set of variables available in the Census removes all sources of confounding. With data from the United States, Chay, Dobkin, and Greenstone (19) have documented the sensitivity of the estimated TSPs-mortality relationship to small changes in specification which is consistent with the possibility that omitted variables bias plagues the conventional approach.

The second approach leverages the regression discontinuity (RD) design implicit in the Huai River policy (20). This design can be used to assess the impact of the policy on TSP concentrations and life expectancy. Additionally we embed the RD design in a two-stage least squares approach, to obtain estimates of the impact of TSP on the outcome variables. This RD approach is based on the assumption that omitted variable change "smoothly" in distance from the river and that by including polynomials in distance from the river it is possible to adjust away all confounding or sources of omitted variables bias. This approach is then based on a test for a discontinuous change in outcomes at the river.

Specifically, we estimate the following equations to test for the impacts of the Huai River policy:

$$TSP_j = \alpha_0 + \alpha_1 N_j + \alpha_2 f(L_j) + X_j \kappa + \nu_j \qquad (2a)$$

$$Y_j = \delta_0 + \delta_1 N_j + \delta_2 f(L_j) + X_j \phi + \upsilon_j \qquad (2b)$$

where N_j is an indicator variable equal to 1 for cities that are North of the Huai River line, $f(L_j)$ is a cubic polynomial in the degrees north of the Huai River line for city j, and the other variables are the same as in equation (1).

Under the assumption that the only determinant of mortality affected by the Huai River Policy is TSP, it is valid to treat equation (2a) as the first stage in a two-stage least squares system of equations. The second stage equation is:

$$Y_j = \beta_0 + \beta_1 \hat{TSP}_{jt} + \beta_2 f(L_j) + X_j \Gamma + \varepsilon_{jt} \qquad (2c)$$

where $\hat{TSP}_{jt}$ represents the fitted values from estimating (2a) and the other variables are as described above. If the RD design is valid and the Huai River Policy only affects mortality through its impact on TSP, the estimation of (2c) will produce an unbiased estimate of the impact of TSP on mortality rates and life expectancy. In other words, it offers the prospect of solving the confounding or omitted variables problem.

IV. Results

Table 1 reports on summary statistics of some of the key determinants of mortality rates. Columns (1) and (2) report the means (standard deviation) in cities North and South of the Huai River line. Column (3) reports the results from a test of whether the means are equal in the

North and South, with the standard error report below the difference in parentheses. Column (4) repeats this test but this time the difference is adjusted for a cubic polynomial in degrees north of the Huai River so that it is a test for a discontinuous change at the Huai River line. A direct test of the RD design's assumption that unobservables change smoothly at the boundary is, of course, impossible but it would nevertheless be reassuring if observable determinants change smoothly at the boundary. Column (5) reports the p-values associated with these two tests.

Panel 1 of Table 1 reports large differences in TSP exposure among Northern and Southern Chinese residents. The average recorded measure for long-run TSP exposure is 580 $\mu g/m^3$ in the North but only 365 $\mu g/m^3$ among cities in the South. Notably, the difference remains roughly the same, 248 $\mu g/m^3$, after adjustment for the polynomial in latitude degrees north of the river. Interestingly, we fail to find a discontinuous change in the other measured air pollutants (sulfur dioxide and nitrogen oxides) at the border which supports the validity of the two-least squares approach for examining the direct impact of TSP on health, without confounding from other toxins.

Figure 2 reports the results from this test graphically. Specifically, it plots cities' TSP concentration against their degrees north of the Huai River boundary. The line is the fitted value from the estimation of the first-stage equation (2a), without adjustment for X_j. The discontinuous increase in ambient TSP concentrations to the north of the border is striking. This demanding RD test suggests that Huai River Policy caused dramatically higher TSP concentrations in the North.

Panel 2 repeats this exercise for each of the available control variables from the Census and DSP separately. The final row reports on the predicted life expectancy, where the prediction is from an OLS regression of life expectancy on the covariates in the preceding rows (excluding TSP). There are some unexpected differences in a few of the covariates at the boundary (e.g., share in manufacturing). However, the final row's finding that the null of equal predicted life expectancy (i.e., a linear combination of these covariates) at the border is reassuring about the validity of the RD design. Figure 3 reports on this finding graphically, using the same methods as in Figure 1.

Panel 3 helps to underscore the power of the RD design. It reveals that there are substantial differences in temperatures measured by heating and cooling degree days (both use a base of 65^0F) between the North and South. However, after adjustment for the cubic polynomial in latitude, these differences are greatly reduced and are not statistically meaningful.

Table 2 reports the results from the application of the conventional OLS approach. It shows the results from the estimation of equation (1) with four different dependent variables--the overall mortality rate, the lung related mortality rate, the non lung related mortality rate, and life expectancy. The set of controls are reported at the top of the table. The first three rows suggest that a 100 μg/m^3 increase in TSP is associated with a modest in magnitude but statistically significant increase in the mortality rate of 2.5%-3% and this is entirely due to increases in lung related causes of death. The final row indicates that a 100 μg/m^3 increase in TSPs is associated with a loss in life expectancy of about 0.5-0.6 years.

Table 3 presents the RD results from the estimation of equations (2a) and (2b) in Panel 1 and the two-stage least squares results from (2c) in Panel 2. The first row of Panel 1 confirms that impact of the Huai River policy on TSP is robust to adjustment for the covariates. The remaining rows suggest that this policy increases mortality rate by 22%-25% and that this is almost entirely due to higher rates of mortality among lung related causes. The estimates in the final row indicate that there is a discontinuous decrease in mortality rates to the north of the boundary of approximately 5 years. This is confirmed graphically in Figure 4.

Under the two-stage least squares exclusion restriction assumption, it is appropriate to compare the Panel 2 results to those in Table 2. These estimates are substantially larger than the corresponding OLS results from the estimation of equation (1). For example, the point estimates suggest that a 100 μg/m^3 increase in TSP is associated with an increase in the overall mortality rate of 9%-14% and a decline in life expectancy of 2-3 years. Again, the result appears to be driven entirely by higher lung related causes of death.

As noted, our results indicate much larger costs in life expectancy from air pollution using the two-stage least squares approach than the conventional OLS method. The difference suggests that the simple correlation between air pollution and health outcomes understates the true effect, provided that the Huai River Policy is a valid natural experiment. We interpret this difference as evidence that China's air pollution is correlated with regional variation in wealth that may mitigate the health consequences of high TSP levels in the OLS results. For example, in many Northern Chinese cities, industrialization has been associated with increasing wealth and deteriorating air quality. If inhabitants of these cities are able to partially mitigate the health consequences of the air pollution by gaining better access to medical care, our OLS results will understate the true causal impact of air pollution. While other interpretations for the large difference between OLS and 2SLS estimates may exist, it is worthwhile to note that both estimates indicate significant health consequences to exposure to TSP levels like those observed in China.

Figure 5 depicts the results of the estimation of equation (2c) for the lung related mortality rate separately for each of the available age categories. These results are noisier than the overall results but several of the estimates would still be judged statistically significant at conventional levels. The interesting finding is that the overall results appear to be driven by higher rates of mortality for ages 25 and older. A more detailed set of results is provided in Appendix Table 1, which provides separate by age estimates for lung and non-lung related mortality rates. Overall, these results provide new evidence that sustained exposure to TSP raises mortality rates throughout the life cycle, not just among the elderly.

Finally, we performed a set of robustness checks to ascertain how decisions in our sample selection or functional form assumptions affected our results [see the supporting online materials for a full description]. These included restricting the sample to DSP sites very near the air quality monitoring station and using higher order polynomials of latitude in our controls. These exercises did not change the results qualitatively.

Several caveats to our analysis are worth noting however, and are discussed in greater detail in the supplementary online material. Our data has no information on the decedent's diet, smoking habits or other behaviors that might affect cause-specific mortality rates. We present evidence in the supplementary online materials that these confounders are uncorrelated with air pollution. It is also worth noting that our data is also only for a subset of cities with air quality data, and so cannot be fully generalized to the Chinese population. Furthermore, the use of the two-stage least squares parameter estimates outside of the Chinese context may be inappropriate due to nonlinearities in the TSP-human health relationship. For example, the levels we observe during this period for China are more than 5 times as high as readings taken for major cities in the United States today.

V. Conclusions

This paper has examined the long-term health consequences of exposure to high TSP levels, as seen in China during the last several decades. Our empirical strategy is to take advantage of the natural experiment associated with China's Huai River Policy, where we are able to observe populations otherwise similar but exposed to different levels of TSP. We find that additional TSP exposure is costly in terms of life expectancy, and this cost is almost five times more costly in terms of life expectancy than the simple correlation would suggest. While we are unable to control for all possible confounders, our results indicate that TSP exposure is costly in terms of life expectancy – roughly 2.5 years per 100 μg/m^3. We also find evidence that this occurs throughout the life-cycle, not only at older ages. Our results may provide a potential explanation for China's anemic growth in life expectancy in spite of its robust economic growth. Our study suggests that policymakers should consider policies that induce reduction in TSP levels, such as the adoption of cleaner types of coal (21-22).

References and Notes

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Table 1

Summary Statistics, Means and (Standard Deviations)

	South	North	Difference In Means	Adjusted Difference In Means	p-value
	(1)	(2)	(3)	(4)	(5)
Panel 1: Air Pollution Exposure at China's Disease Surveillance Points					
Total Suspended Particulates (μg/m^3)	364.92	580.25	215.33***	247.50***	<.001/<.001
	(175.7)	(185.8)	(41.15)	(65.16)	
Sulphur Dioxide (μg/m^3)	94.24	97.61	3.38	6.64	0.802/0.774
	(81.3)	(58.9)	(13.44)	(23.06)	
Nitrous Oxide (μg/m^3)	39.55	54.06	14.51***	-4.32	<.001/0.476
	(17.7)	(17.1)	(3.86)	(6.04)	
Panel 2: Demographic Characteristics of China's Disease Surveillance Points					
Years of Education	7.23	7.57	0.34	-0.65	0.187/0.171
	(1.39)	(1.36)	(0.25)	(0.47)	
Share in Manufacturing	0.14	0.11	-0.03	-0.15***	0.202/0.002
	(0.12)	(0.10)	(0.02)	(0.05)	
Share Minority	0.11	0.05	-0.05	0.04	0.132/0.443
	(0.24)	(0.13)	(0.04)	(0.05)	
Share Urban Hukou	0.42	0.42	0.00	-0.20*	0.999/0.088
	(0.30)	(0.32)	(0.06)	(0.12)	
Share Tap Water	0.50	0.51	0.02	-0.32**	0.821/0.035
	(0.33)	(0.34)	(0.07)	(0.15)	
Rural, Poor	0.21	0.23	0.01	-0.33*	0.879/0.09
	(0.41)	(0.42)	(0.09)	(0.19)	
Rural, Middle Income	0.34	0.33	0.00	0.24	0.979/0.308
	(0.48)	(0.48)	(0.11)	(0.24)	
Rural, High Income	0.21	0.19	-0.02	0.27	0.772/0.141
	(0.41)	(0.39)	(0.08)	(0.18)	
Urban	0.24	0.25	0.01	-0.19	0.859/0.241
	(0.43)	(0.44)	(0.08)	(0.16)	
Predicted Life Expectancy (years)	73.9	75.5	1.58***	-0.47	<.001/0.612
	(2.81)	(2.40)	(0.49)	(0.93)	
Panel 3: Weather Patterns at the Disease Surveillance Points					
Total Heating Degree Days (000s)	2974.8	6199.4	3,224.65***	465.20	<.001/0.191
	(1361.85)	(2022.80)	(417.60)	(353.60)	
Total Cooling Degree Days (000s)	2005.5	1136.0	-869.50***	-240.90	<.001/0.176
	(786.64)	(477.97)	(131.60)	(177.00)	

* significant at 10% ** significant at 5%. *** significant at 1%.

Source : China Disease Surveillance Points (1991-2000), China Environmental Yearbooks (1981-2000), World Meteorological Association (1980-2000).

Note : N=125. The sample is restricted to DSP points within 150 kilometers of an air quality monitoring station. TSP (μg/m^3) in the years 1981-2000 prior to the DSP period is used to calculate city-specific averages. Degree days are the absolute value of the deviation of each day's average temperature from 65^0 F, averaged over the years 1981-2000 prior to the DSP period. The results in column (4) are adjusted for a cubic in degrees of latitude north of the Huai river boundary. Predicted life expectancy is calculated by OLS using all the demographic and meteorological covariates shown. All results are weighted by the population at the DSP site. One DSP site is excluded due to invalid mortality data.

Table 2

Impact of Total Suspended Particulates (100 $\mu g/m^3$) on Health Outcomes Using Conventional Strategy (Ordinary Least Squares)

	No Controls	Census Controls	DSP Controls	Census and DSP Controls
	(1)	(2)	(3)	(4)
ln(Total Death Rate)	0.0255*	0.0284**	0.0268**	0.0270**
	(0.0140)	(0.0139)	(0.0111)	(0.0127)
ln(Lung Related Illnesses)	0.0399**	0.0414**	0.0358**	0.0392**
	(0.0177)	(0.0172)	(0.0146)	(0.0158)
ln(Non Lung Related Illnesses)	0.007	0.013	0.016	0.012
	(0.0160)	(0.0170)	(0.0141)	(0.0160)
Life Expectancy	-0.544**	-0.557**	-0.577***	-0.518**
	(0.256)	(0.237)	(0.198)	(0.227)

* significant at 10% ** significant at 5%. *** significant at 1%.

Source : China Disease Surveillance Points (1991-2000), China Environmental Yearbooks (1981-2000), World Meteorological Association (1980-2000).

Note : N=125. The sample is restricted to DSP points within 150 kilometers of an air quality monitoring station. Each cell in the table represents the coefficient from a separate regression, and the standard error of the coefficient is reported below in parentheses. The lung-related illnesses are heart disease, stroke, lung cancer and other respiratory illnesses. The non-lung related illnesses are violence, cancers other than lung, and all other causes. Models in column (2) include controls for average education, share employed in manufacturing, share minority, share with urban registration, share with tap water. Models in column (3) include controls for the wealth level of the DSP site. Models in column (4) include the controls in (2) and (3). All models include controls for the heating and cooling degrees days between 1981 and 2000 prior to the year being analyzed. Degree days are the sum of the difference between the temperature and 65^0F. Regressions are weighted by the population at the DSP site.

Table 3

Using the Huai River Policy to Estimate the Impact of Total Suspended Particulates (100 μg/m^3) on Health Outcomes

	Cubic in Latitude	Cubic and Census Controls	Cubic and DSP Controls	Cubic, Census, and DSP
	(1)	(2)	(3)	(4)
Panel 1: Impact of "North" on the Listed Variable, Ordinary Least Squares				
TSP (100 μg/m^3)	2.475***	1.874***	2.047***	1.839***
	(0.6520)	(0.6380)	(0.6750)	(0.6340)
ln(Total Death Rate)	0.219*	0.229*	0.225*	0.257*
	(0.1310)	(0.1350)	(0.1280)	(0.1310)
ln(Lung Related Illnesses)	0.373**	0.363**	0.380**	0.379**
	(0.1550)	(0.1680)	(0.1540)	(0.1630)
ln(Non Lung Related Illnesses)	-0.0038	0.0300	0.0122	0.0772
	(0.1260)	(0.1320)	(0.1210)	(0.1280)
Life Expectancy (years)	-5.039**	-5.540**	-4.313*	-5.523**
	(2.4720)	(2.3920)	(2.4980)	(2.3850)
Panel 2: Impact of TSP (100 μg/m^3) on the Listed Variable, Instrumental Variables				
ln(Total Death Rate)	0.0884*	0.122*	0.110*	0.140**
	(0.049)	(0.069)	(0.061)	(0.069)
ln(Lung Related Illnesses)	0.151**	0.194**	0.186**	0.206**
	(0.059)	(0.091)	(0.080)	(0.092)
ln(Non Lung Related Illnesses)	-0.0015	0.0160	0.0059	0.0420
	(0.051)	(0.069)	(0.058)	(0.067)
Life Expectancy (years)	-2.036**	-2.957**	-2.106*	-3.004**
	(0.922)	(1.280)	(1.169)	(1.328)

* significant at 10% ** significant at 5%. *** significant at 1%.

Source : China Disease Surveillance Points (1991-2000), China Environmental Yearbooks (1981-2000), World Meteorological Association (1980-2000).

Note : N=125. The sample is restricted to DSP points within 150 kilometers of an air quality monitoring station. Each cell in the table represents the coefficient from a separate regression, and the standard error of the coefficient is reported below in parentheses. The lung-related illnesses are heart disease, stroke, lung cancer and other respiratory illnesses. The non-lung related illnesses are violence, cancers other than lung, and all other causes. Models in column (1) include a cubic in latitude. Models in column (2) additionally include controls for average education, share employed in manufacturing, share minority, share with urban registration, share with tap water. Models in column (3) include the wealth level of the DSP site. All models include controls for the heating and cooling degrees days between 1981 and 2000 prior to the year being analyzed. Degree days are the sum of the difference between the temperature and 65^{0}F. Regressions are weighted by the population at the DSP site.

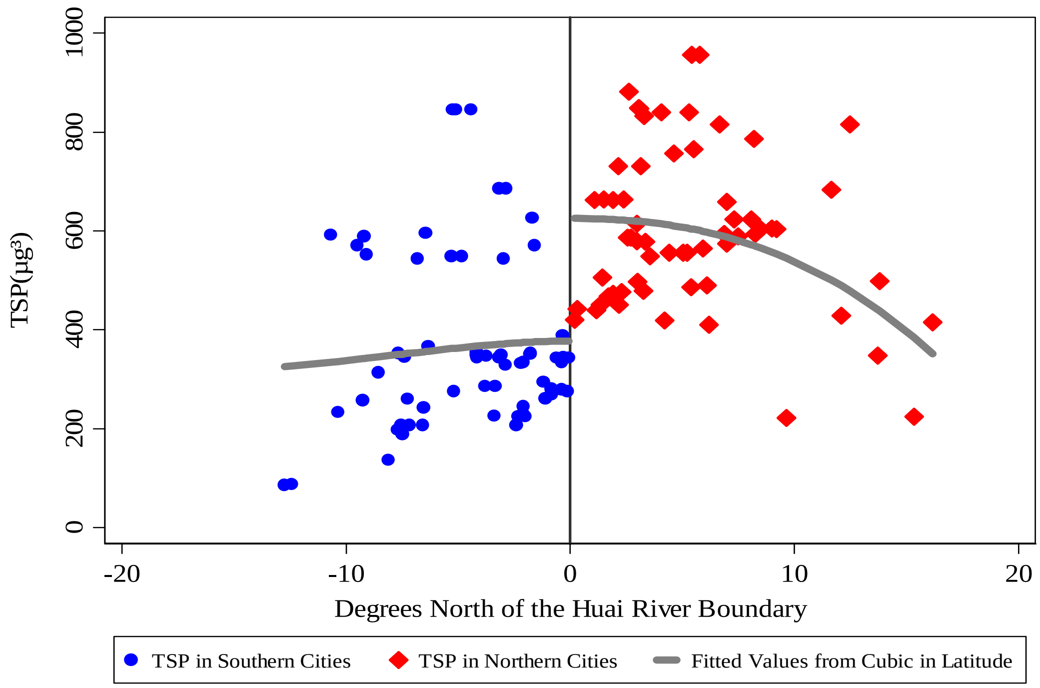
Figure 1

North and South China Denoted by Huai River/Qinling Mountains 0° Celsius Line

Note : The cities shown are the locations of the air quality monitoring stations in China. Cities north of the solid line were covered by the home heating policy.

Figure 2

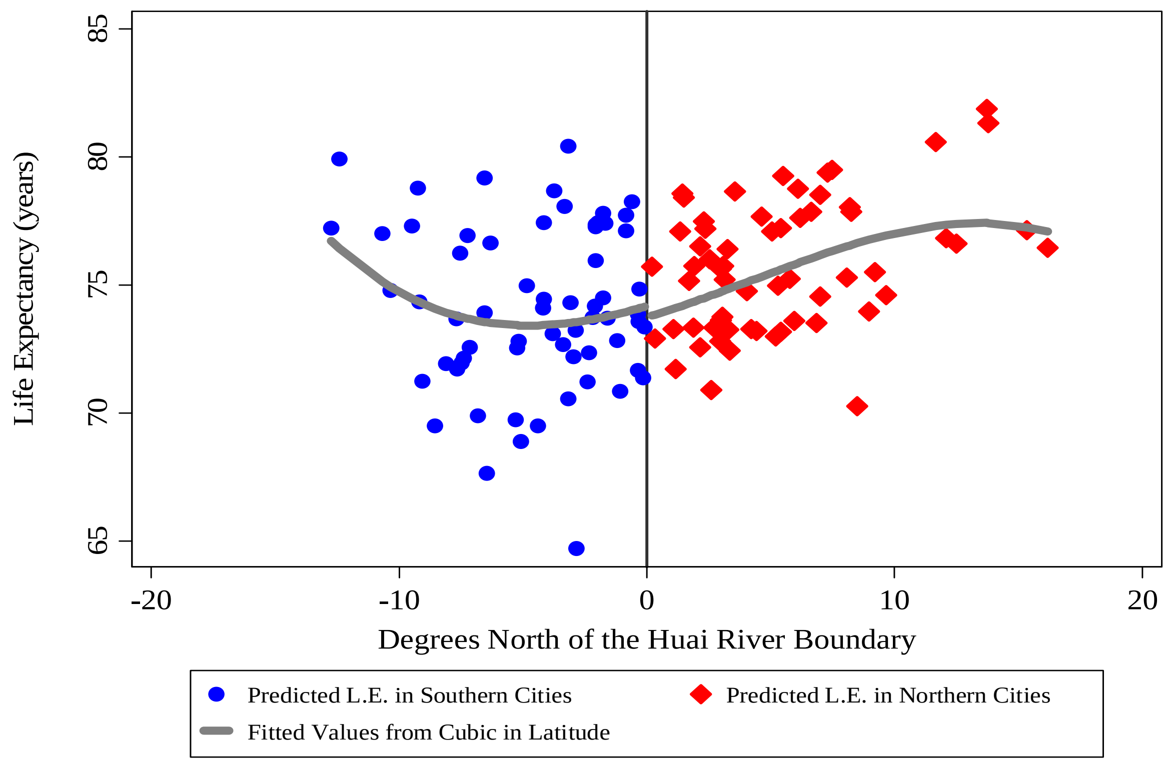
Total Suspended Particulate Concentration Exposure among Chinese Disease Surveillance Points by Distance from Huai River Boundary



Note : Each observation is a Disease Surveillance Point site, with the average TSP reading assigned from China's air quality monitoring stations. Readings are taken from China's Environmental Yearbooks (1981-2000).

Figure 3

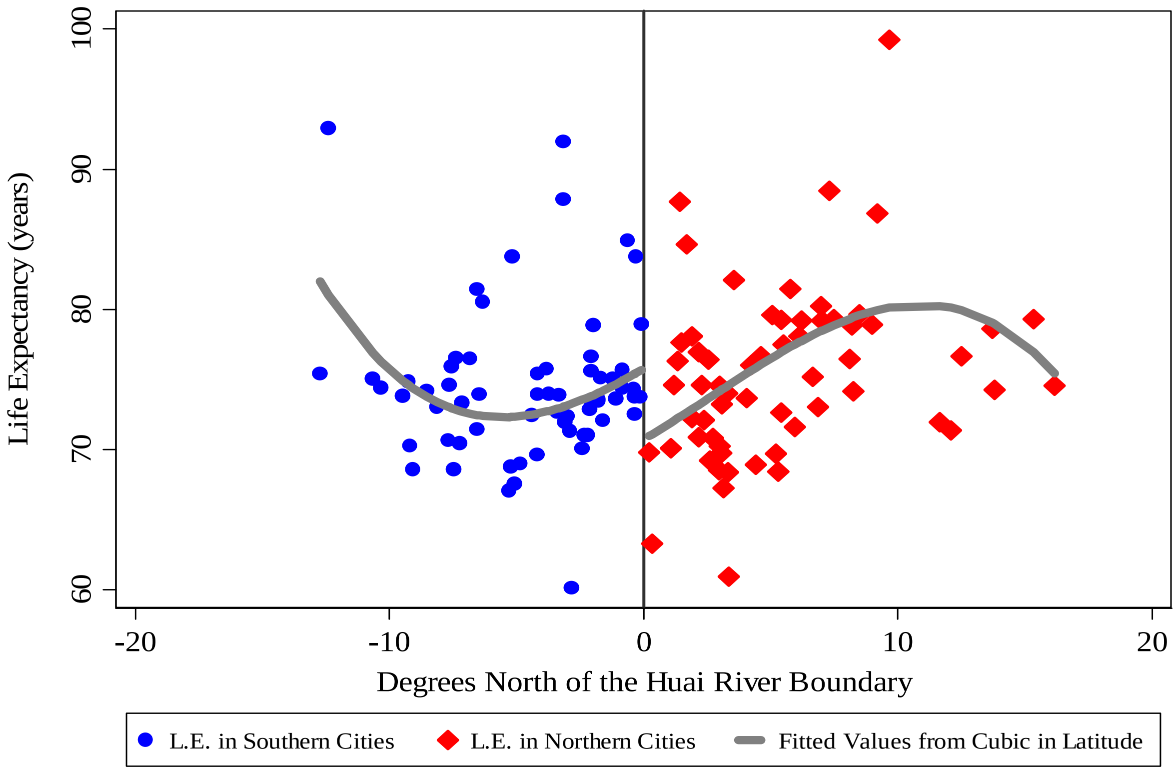
Predicted Life Expectancy among Chinese Disease Surveillance Point Sites by Distance from Huai River Boundary



Note : Each observation is a Chinese Disease Surveillance Point. Life expectancy is calculated from the mortality rates at each Disease Surveillance Point site. Predicted life expectancy is calculated by OLS using the demographic and meteorological covariates listed in Panel 2 and 3 of Table 1.

Figure 4

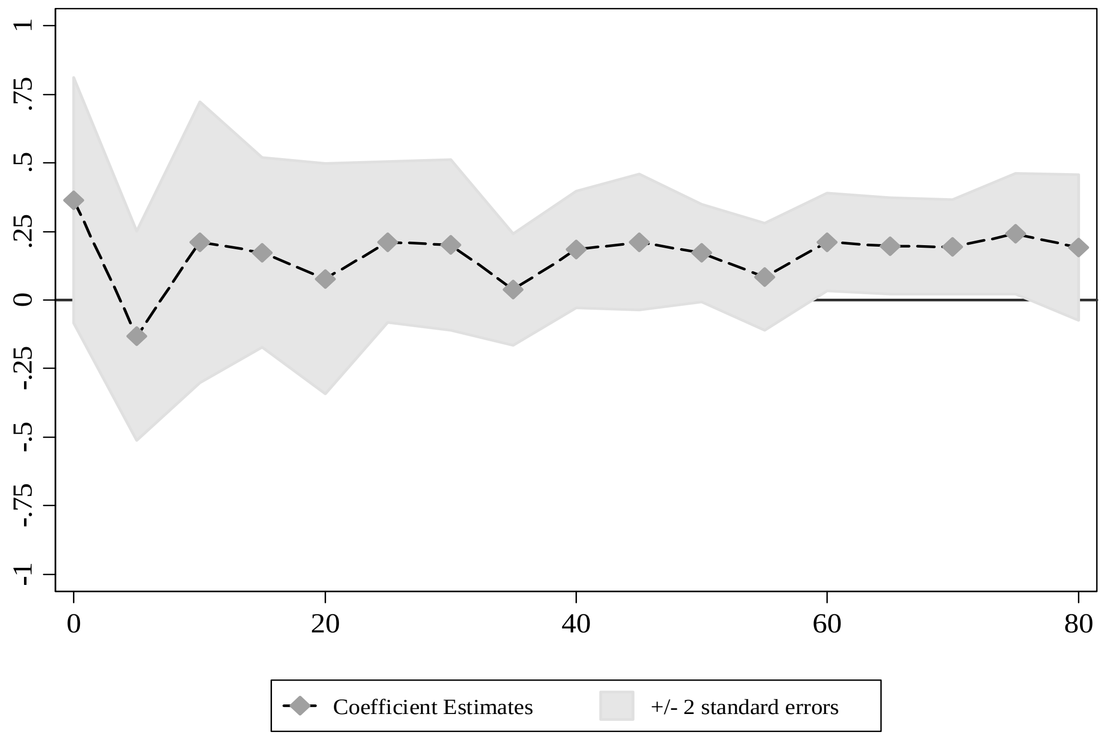
Life Expectancy among Chinese Disease Surveillance Point Sites by Distance from Huai River Boundary



Note : Each observation is a Chinese Disease Surveillance Point, and the average life expectancy implied by the mortality rates at the site. Mortality rates are taken from 1991-2000 for each Disease Surveillance Point site.

Figure 5

Estimated Impact of Long-Term TSP exposure (1981-2000) on Lung-Related Illnesses by Age using the Huai River Policy (Instrumental Variables)



Note : Each point in the plot represents the coefficient from a separate regression, where we examine how the log of age-specific death rates are affected by long-term exposure to TSP (μg/m^3). The IV regressions are estimated in the manner described in Table 3, where the log of the death rate from lung related illnesses is the dependent variable and long-term TSP average is the independent variable. The models are estimated using 1(North) as the instrument for average TSP.

Appendix Table 1

Using the Huai River Policy to Estimate the Impact of Total Suspended Particulates (100 μg/m^3) on Health Outcomes

Age	Lung Related Illnesses	Nonlung Related Illnesses	Differnce (1)-(2)	p-value
	(1)	(2)	(3)	(4)
0	0.2826	0.6086	-0.3533	0.1802
	(0.259)	(0.256)	(0.264)	
1	-0.4399	-0.3427	-0.0337	0.8568
	(0.344)	(0.213)	(0.187)	
5	-0.0902	-0.1121	-0.0961	0.6040
	(0.195)	(0.144)	(0.185)	
10	0.2380	-0.0976	0.3292	0.2415
	(0.276)	(0.174)	(0.281)	
15	0.1737	-0.0370	0.2253	0.2976
	(0.2)	(0.155)	(0.216)	
20	0.0695	0.1038	-0.0862	0.6323
	(0.248)	(0.106)	(0.18)	
25	0.2248	0.1231	0.0999	0.4874
	(0.172)	(0.097)	(0.144)	
30	0.2458	-0.0565	0.3037	0.0668*
	(0.188)	(0.098)	(0.166)	
35	0.0310	0.0532	-0.0219	0.8358
	(0.121)	(0.082)	(0.106)	
40	0.2059	0.0997	0.1062	0.3047
	(0.127)	(0.078)	(0.103)	
45	0.2520	0.0131	0.2388	0.0692*
	(0.151)	(0.085)	(0.131)	
50	0.2058	-0.0081	0.2139	0.0674*
	(0.106)	(0.093)	(0.117)	
55	0.0939	-0.1039	0.1978	0.0613*
	(0.116)	(0.126)	(0.106)	
60	0.2287	0.1442	0.0845	0.3659
	(0.106)	(0.121)	(0.093)	
65	0.2123	0.0659	0.1465	0.1590
	(0.105)	(0.102)	(0.104)	
70	0.2145	0.0350	0.1796	0.0982*
	(0.102)	(0.101)	(0.109)	
75	0.2775	0.1011	0.1765	0.1522
	(0.133)	(0.123)	(0.123)	
80	0.2056	-0.0104	0.2160	0.1399
	(0.154)	(0.162)	(0.146)	

* significant at 10% ** significant at 5%. *** significant at 1%.

Source : China Disease Surveillance Points (1991-2000), China Environmental Yearbooks (1981-2000), World Meteorological Association (1980-2000).

Note : N=125. The sample is restricted to DSP points within 150 kilometers of an air quality monitoring station. Each cell in the table represents the coefficient from a separate regression, and the standard error of the coefficient is reported below in parentheses. The models are estimated as described in Table 3, using the saturated specification shown in column 4. The standard errors of the differences of the estimator are estimated by 3SLS.