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HIGH STAKES ENERGY AND ENVIRONMENTAL PROBLEMS IN DEVELOPING COUNTRIES

Growth, Pollution, and Life Expectancy: China from 1991–2012†

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In the past two decades, China has experienced economic growth without historical precedent, with average income rising from $894 per capita to $9,087 (PPP). However, this incredible surge in income has not been matched by comparable health gains; life expectancy at birth increased by 5.4 years, a modest gain relative to neighboring countries such as Taiwan or South Korea (World Bank 2012). Furthermore, much of the improvement in Chinese life expectancy came from reductions in infant and child mortality which were "low hanging fruits," as China pulled millions of its citizens out of abject poverty and instituted basic improvements in sanitation and public health. In contrast, the gains in adult health outcomes have been considerably smaller, in spite of the ten-fold increase in average income. Adult mortality fell faster in Taiwan, South Korea, and even Japan during this period—all countries with economic growth less than half as robust as China's. This puzzling trend has begun to attract considerable attention (Yang et al. 2013) and begs an obvious question: Why has China failed to enjoy a larger improvement in health amidst such astonishing economic growth?

One explanation for China's modest growth in life expectancy is the country's severe problems with air pollution. Since pollution is a byproduct of economic development, it may be that the benefits of greater income are offset by the cost of pollution exposure. This possibility has long been raised by those criticizing the emphasis on economic development above other priorities in low income countries. However, microeconometric evidence in favor of this hypothesis is scarce, possibly due to data limitations. Detailed cause of death data in developing countries are often unavailable, or available only at a national level. Similarly, local measures of economic growth are often unavailable or of low quality. As such, an accurate assessment of the benefits and costs of economic growth on pollution and mortality is often infeasible.

This paper examines the changes in Chinese mortality patterns using the most comprehensive data file ever compiled on health, pollution, and income in China. Importantly, these data cover the period 1991–2012, when China experienced its unprecedented economic boom. The analysis is conducted using detailed mortality data taken from China's Disease Surveillance Points System (DSPS), a mortality-monitoring system covering a nationally representative sample of Chinese cities and counties. These data are linked to air pollution data for 1980–2012 taken

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from physical copies of China's *Environmental Yearbooks* and electronic files provided by China's National Environmental Protection Agency. Lastly, we assign to each DSPS location a measure of local per capita GDP, facilitating an analysis of both the role of pollution and income growth in affecting health.

We present two analyses that suggest that China's air pollution is associated with its modest improvement in health outcomes. First, we document in the time series that causes of death which are presumably affected by pollution have declined much more slowly than other causes of death. In particular, heart disease, stroke, and lung cancer have remained at similar levels through the 1990s and 2010s, and these cardiorespiratory illnesses now comprise a much larger share of Chinese mortality. In contrast, mortality rates from noncardiorespiratory illnesses, such as communicable diseases, have declined much more rapidly over the same period. Communicable disease mortality rates are very likely to be responsive to hospital construction and public health initiatives, but less sensitive to pollution. As such, the cause-specific mortality trends suggest that China's income growth has improved health outcomes, but failed to do so for pollution-sensitive causes of death.

Second, we examine the association between health outcomes, income, and pollution across regions of China. In cross-sectional models, we find that income growth is associated with gains in life expectancy that are driven by declines in noncardiorespiratory mortality rates. High pollution exposure is associated with declines in life expectancy, but this effect would not be judged statistically significant by conventional criteria. There is, however, a statistically significant relationship between pollution exposure and higher rates of cardiorespiratory mortality. We also estimate first-difference models where we examine changes across DSPS locations in mortality patterns between the beginning and end of our sample period, 1991–1993 and 2010–2012. We find that declines in particulate air pollution are associated with increases in average life expectancy and lower rates of cardiorespiratory mortality. The results suggest that air pollution may in fact be an important factor in explaining China's modest growth in life expectancy during a period of rapid economic development. However, these associational findings need to be probed further with quasi-experimental research designs that isolate plausibly exogenous variation in pollution (Dominici et al. 2014).

I. Economic Development and Pollution

The health consequences of pollution in developing countries are difficult to isolate because income growth often occurs simultaneous to increases in pollution (and indeed may be a function of pollution), making it difficult to isolate the causal effect of pollution. More formally, consider a simple specification where life expectancy (L) is a function of income I and pollution P and income is a function of pollution:

$$L = H(I(P), P)$$

$$\frac{dL}{dP} = \frac{\partial H(I,P)}{\partial P} + \frac{\partial H(I,P)}{\partial I}\frac{\partial I}{\partial P}.$$

In this setup, a regression of life expectancy on pollution confounds the positive effects of income growth with the potentially harmful consequences of pollution. Rather, it represents the net effect of pollution on health through the direct effect on life expectancy and an indirect effect through pollution's impact on income. Since some policy options involve changes in pollution that do not affect local incomes, it is critical to obtain the partial derivative of life expectancy with respect to pollution, rather than the total derivative. The next section outlines the data sources that we have amassed to infer this relationship using data from China over the last two decades.

II. Data Sources and Descriptive Statistics

Our analysis is executed on a merged sample of health, pollution, and income data between 1991 and 2012. The mortality data are taken from the DSPS, a nationally representative sample with coverage of 145 locations between 1991 and 2000 and 161 locations between 2004 and 2012. The pollution data are taken from China's *Environmental Yearbooks*, which contain measures of pollution from the early 1980s and through our sample period, and are described in great depth in the online Appendix. Gross Domestic Product per capita is calculated for each DSPS location using income and

Table 1— Trends in Health, Income, and Pollution in China, 1991–2012

	1991	2000	2012
Life expectancy at birth	69.3 (6.6)	71.5 (5.6)	75.7 (3.5)
Life expectancy at age 5	67.1 (5.9)	68.1 (5.1)	71.4 (3.3)
All cause mortality (per 100,000)	863.4 (305.4)	821.2 (341.2)	531.7 (135.7)
Cardiorespiratory diseases	432 (214.8)	463.4 (236.6)	310.3 (100.1)
Noncardiorespiratory diseases	431.5 (203.3)	357.8 (158.5)	221.4 (59.7)
GDP per capita (2010 yuan)	4,317 (2,167)	9,546 (5,320)	40,151 (16,052)
Particulate matter (PM_{10}, $\mu g/m^3$)	111.3 (41.8)	87.9 (44.4)	80.1 (21.0)

Notes: Author calculations using the Chinese Disease Surveillance Points Survey (1991–2012). Income data is taken from China's *Statistical Yearbooks*. Pollution measures are taken from China's *Environmental Yearbooks* (1981–2012). Fine particulate matter is imputed in 1991 by assuming a fixed proportion of Total Suspended Particulates.

population data from the *Provincial and City Statistical Yearbooks*. Lastly, the DSPS locations are merged with demographic information from the 1990 and 2010 census to obtain county-level information on average education, share of minority, and share with urban *hukou* (household registration).

The sample means are reported in Table 1 which compares China in 1991, 2000, and 2012: before, during, and after its explosive economic growth. The summary statistics are reported for the subsample of DSPS locations used in our analysis by virtue of having a nearby pollution monitoring station; 136 DSPS locations for 1991–2000, and 154 DSPS locations in 2012. Several noteworthy patterns are immediately evident. First, life expectancy increased by 6.4 years between 1991 and 2012, raising average longevity from 69.3 to 75.7 years. However, much of the gain was from under-five mortality, as life expectancy at age five remained only 71.4 years, which is 4.3 years higher than two decades prior. The explanation for this comparatively modest improvement is found in the breakdown of cause-specific death rates, where we find striking differences between cardiorespiratory diseases versus the rest of causes of death. Noncardiorespiratory diseases, which include most communicable diseases and causes of death relevant to infants and young children, dropped dramatically from 432 to 221 deaths per 100,000. This is consistent with our understanding that China's rapid economic growth has enabled it to implement widespread improvements in public health and sanitation, thereby reducing mortality from diseases affecting the young. However, the results are more sobering for cardiorespiratory diseases: mortality from heart diseases, stroke, and lung cancer remained virtually unchanged during the period. These diseases are known to be sensitive to air pollution, as documented by a rich medical literature (see Chen et al. 2013 for references). The results suggest that pollution-related diseases have continued to have high mortality rates in China, in spite of robust economic growth that appears to have facilitated substantial declines in other causes of death. The table also highlights China's rapid income growth, in which average per capita GDP rose by a factor of 10 at the DSPS locations, from an average of 4,317 yuan (~\$900) to 40,151 (~\$6,360) in real terms.[1] In the table's final row, we report trends in particulate air pollution. Since China's monitoring system has not consistently monitored fine particulate matter (PM_{10}) for the entire period, we impute PM_{10} from the Total Suspended Particulates (TSP) reading. This is calculated using the assumption that PM_{10} represents 37.5 percent of TSP, the observed proportion in instances where both measures were collected. As shown in the table, the data reveal a striking *decline* for two of the air pollutants in the previous two decades. For example, PM_{10} declines from 111.3 to 80.1 micrograms per cubic meter ($\mu g/m^3$) in the two decades; this decrease of 33.3 $\mu g/m^3$ is more than the absolute level of pollution in many countries.

In this paper, we examine the consequences of pollution exposure in the long run. We define long-run pollution exposure as the average pollution reading assigned to the DSP location in all years prior to the observed year, and including the year itself. As a result, while the declines in annual pollution in Table 2 are substantial, their influence on lifetime exposure is more

[1] We use 1:4.78 and 1:6.3 to convert RMB to USD in 1990 and 2012. All yuan figures are adjusted for the Chinese CPI and reported in 2010 yuan.

Table 2— Estimating the Relationship Between Health, Income, and Pollution

	Life expectancy at birth (years) (1)	Life expectancy at age 5 (years) (2)	Cardiorespiratory mortality rate (per 100,000) (3)	Noncardiorespiratory mortality rate (per 100,000) (4)
Panel A. Cross-sectional models using DSP locations in 1991–2000				
log of per capita GDP	3.53***	1.71*	−38.8	−121.4***
	(1.03)	(0.96)	(25.8)	(24.5)
TSP (100 μg/m^3)	−0.15	−0.32	25.0***	−10.6*
	(0.27)	(0.26)	(9.1)	(5.9)
R^2	0.074	0.032	0.083	0.156
Panel B. Cross-sectional models using DSP locations in 2004–2012				
log of per capita GDP	2.21***	1.51***	−31.1*	−51.4***
	(0.56)	(0.52)	(15.8)	(12.2)
PM_{10} (100 μg/m^3)	−0.71	−0.73	50.5***	−20.3*
	(0.54)	(0.47)	(13.3)	(10.8)
R^2	0.092	0.061	0.113	0.120
Panel C. First differences comparing DSP locations in 1991–1993 and 2010–2012				
log of per capita GDP	2.40***	1.28**	−46.7***	−88.2***
	(0.57)	(0.56)	(14.5)	(13.1)
PM_{10} (100 μg/m^3)	−1.55	−2.27**	78.6**	45.6
	(1.10)	(1.05)	(37.4)	(51.1)
R^2	0.348	0.204	0.381	0.519

Notes: The sample in panel A is composed of 136 DSP locations, and 154 DSP locations in panel B. The sample in panel C is restricted to 84 locations observed both periods. The outcome variable in each column is a collapsed measure of the health outcomes across the years in the listed period. In panels A and B, we regress health outcomes on levels of pollution and local income and in panel C, we regress changes in health outcomes on changes in pollution and local GDP, comparing 1991–1993 to 2010–2012.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

muted when using our long-run measures. For example, the population at a DSPS location in 1991 and in 2012 will *both* have been exposed to the 1980s pollution at the location. Therefore, both the level and timing of a pollution decline will factor into our estimated pollution exposure at any given DSPS location.

III. Assessing the Relationship between Health, Pollution, and Income

Table 2 presents the results from regressing a series of health outcomes against exposure to particulate matter (TSP and PM_{10}), and per capita GDP. Specifically, we estimate three sets of regressions displayed in panels A, B, and C: cross-sectional with 1991–2000, cross-sectional with 2004–2012, and a first-difference specification where we regress changes in the outcome variables on changes in pollution exposure and changes in per capita GDP between the two periods. Our outcome variables (displayed in the column headers) are life expectancy at birth, life expectancy at age five, age-adjusted death rate from cardiorespiratory mortality, and age-adjusted death rate from all other causes of death.

In panel A, we focus on 1991–2000. The results reflect a strong positive relationship between GDP and life expectancy, driven primarily by its negative impact on the noncardiorespiratory rate. A doubling of income is predicted to have a 3.5 year gain in life expectancy and reduce noncardiorespiratory mortality by 121 deaths per 100,000, or roughly 28 percent from its level in 1991. These findings fit the conventional wisdom; as China began to pull itself from poverty, the first gains were from reductions in infant mortality and childhood diseases, yielding large declines in mortality from these causes of death. Notably, the results fail to find a statistically significant relationship between income and life expectancy at age five. The table also reveals a significant positive association between TSP exposure and cardiorespiratory mortality: an additional 100 $\mu g/m^3$ of TSP raises the cardiorespiratory mortality rate by 25 per 100,000, an increase of roughly 5.8 percent from its level in 1991. Although TSP is negatively correlated with both life expectancy measures, these relationships would not be judged to be statistically significant.

The results in panel B are very similar to those reported in panel A. Here, the sample is composed of DSPS locations observed between 2004 and 2012 and we use direct measurement of PM_{10}. The results are similar in that income growth is positively associated with life expectancy at birth, though with a lower estimated semi-elasticity. Income is again associated with stronger declines in noncardiorespiratory mortality. Finally, particulate matter is positively correlated with cardiorespiratory mortality, with a 100 $\mu g/m^3$ increase in PM_{10} resulting in an increase in the mortality rate from these causes by 50 per 100,000, an increase of over 11 percent.

Panel C presents the results of a first-difference specification that examines the relationship between changes in health and changes in income and pollution between the beginning (1991–1993) and end (2010–2012) of our sample frame.[2] This enables us to compare the same DSPS location after two decades of radical change in China and relies on an alternative source of variation than is utilized in the cross-sectional results in panels A and B. Specifically, the first-differencing purges the estimates of the influence of all time invariant determinants of the health outcomes, such as differences in diet or smoking rates. Of course, the estimates of the effects of GDP and pollution may still be confounded by time-varying DSPS-level factors and the role of measurement error, which may produce greater attenuation bias than in the cross-sectional approach. However, the results suggest that economic growth is a key predictor of growth in life expectancy: a doubling of economic growth is associated with an additional 2.4 years of life expectancy. The first difference results suggest that GDP growth during these two decades is also associated with important declines in *both* cardiorespiratory and noncardiorespiratory diseases. Interestingly, the point estimates are comparable to those from the cross-sectional equations. Overall, the per capita income results suggest that income is protective of health: a doubling is associated with a 2–3 year increase in life expectancy at birth. Since income increased by a factor of ten in this period in real terms and total life expectancy increased by 6.4 years, it appears that there was a countervailing force that reduced life expectancy; we estimate that a 100 $\mu g/m^3$ increase in PM_{10} exposure is associated with a decline in life expectancy of 1.5 years at birth and 2.3 years at age five. These results are suggestive evidence that Chinese counties with greater pollution increases (or smaller pollution decreases) are experiencing slower life expectancy increases and have experienced higher cardiorespiratory mortality rates during adulthood.

[2]The first-difference approach has been used in the US context, and found evidence of an important relationship between exposure to fine particulate matter and health (Pope, Ezzati, and Dockery 2009).

IV. Discussion and Future Directions

In the past two decades, while rapid economic development has led to a decline in China's mortality rate among infants and young children, the health gains have been more modest among adults. A candidate explanation for this trend is long-term exposure to air pollution, which raises the mortality rates from cardiorespiratory diseases. We have presented suggestive evidence that this is indeed the case. In light of these potentially large impacts on well-being, an urgent area for future research is to probe the validity of this paper's findings with quasi-experimental designs where the source of variation in pollution is better understood (Dominici et al. 2014).

REFERENCES

Almond, Douglas, Yuyu Chen, Michael Greenstone, and Hongbin Li. 2009. "Winter Heating or Clean Air? Unintended Impacts of China's Huai River Policy." *American Economic Review* 99 (2): 184–90.

Chen, Yuyu, Avraham Ebenstein, Michael Greenstone, and Hongbin Li. 2013. "Evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River policy." *Proceedings of the National Academy of Sciences* 110 (32): 12936–41.

Dominici, Francesca, Michael Greenstone, and Cass R. Sunstein. 2014. "Particulate Matter Matters." *Science* 344 (6181): 257–59.

Pope, C. Arden, Majid Ezzati, and Douglas W. Dockery. 2009. "Fine-Particulate Air Pollution and Life Expectancy in the United States." *New England Journal of Medicine* 360 (4): 376–86.

World Bank. 1991–2012. "World Development Indicators." http://data.worldbank.org/country.

Yang, Gonghuan, Yu Wang, Yixin Zen, George F. Gao, Xiaofeng Liang, Maigeng Zhou, Xia Wan, et al. 2013. "Rapid Health Transition in China, 1990–2010: Findings from the Global Burden of Disease Study 2010." *Lancet* 381 (9882): 1987–2015.

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1. Xiaoqian Hu, Xueshan Sun, Yuanyuan Li, Yuxuan Gu, Minzhuo Huang, Jingming Wei, Xuemei Zhen, Shuyan Gu, Hengjin Dong. 2019. Potential gains in health-adjusted life expectancy from reducing four main non-communicable diseases among Chinese elderly. *BMC Geriatrics* **19**:1. . [Crossref]
2. Cong Sun, Siqi Zheng, Jianghao Wang, Matthew E. Kahn. 2019. Does clean air increase the demand for the consumer city? Evidence from Beijing. *Journal of Regional Science* **99**. . [Crossref]
3. Beata Gavurova, Peter Toth. 2019. Preventable Mortality in Regions of Slovakia—Quantification of Regional Disparities and Investigation of the Impact of Environmental Factors. *International Journal of Environmental Research and Public Health* **16**:8, 1382. [Crossref]
4. Siqi Zheng, Jianghao Wang, Cong Sun, Xiaonan Zhang, Matthew E. Kahn. 2019. Air pollution lowers Chinese urbanites' expressed happiness on social media. *Nature Human Behaviour* **3**:3, 237-243. [Crossref]
5. Shunwen Bai, Xuedong Zhang, Yue Xiang, Xiuheng Wang, Xinyue Zhao, Nanqi Ren. 2019. HIT.WATER scheme: An integrated LCA-based decision-support platform for evaluation of wastewater discharge limits. *Science of The Total Environment* **655**, 1427-1438. [Crossref]
6. Shunwen Bai, Nanqi Ren, Shijie You, Xinyue Zhao, Yifan Li, Xiuheng Wang. 2019. Modeling the oxygen-depleting potential and spatially differentiated effect of sewage organics in life cycle assessment for wastewater management. *Science of The Total Environment* **655**, 1071-1080. [Crossref]
7. Shuai Chen, Ping Qin, Jie-Sheng Tan-Soo, Chu Wei. 2019. Recency and projection biases in air quality valuation by Chinese residents. *Science of The Total Environment* **648**, 618-630. [Crossref]
8. Janna E. Johnson, Evan J. Taylor. 2019. The long run health consequences of rural-urban migration. *Quantitative Economics* **10**:2, 565-606. [Crossref]
9. Zigan Wang, Luping Yu. 2019. Are Firms with Female CEOs More Environmentally Friendly?. *SSRN Electronic Journal* . [Crossref]
10. Wei Jin, ZhongXiang Zhang. 2019. Capital Accumulation, Green Paradox, and Stranded Assets: An Endogenous Growth Perspective. *SSRN Electronic Journal* . [Crossref]
11. Burcu Ö. Bilir, Tuğba Gökdemir. 2018. Kalkınma Göstergeleri Çerçevesinde Yaşam Beklentisinin Yapısal Eşitlik Modeli İle İncelenmesi. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi* 163-167. [Crossref]
12. Ganshen Zhang, Chuanhua Yu, Maigeng Zhou, Lu Wang, Yunquan Zhang, Lisha Luo. 2018. Burden of Ischaemic heart disease and attributable risk factors in China from 1990 to 2015: findings from the global burden of disease 2015 study. *BMC Cardiovascular Disorders* **18**:1. . [Crossref]
13. Siyu Chen, Chongshan Guo, Xinfei Huang. 2018. Air Pollution, Student Health, and School Absences: Evidence from China. *Journal of Environmental Economics and Management* **92**, 465-497. [Crossref]
14. J. Jiang, L. Luo, P. Xu, P. Wang. 2018. How does social development influence life expectancy? A geographically weighted regression analysis in China. *Public Health* **163**, 95-104. [Crossref]
15. Yue-Jun Zhang, Yan-Lin Jin, Tian-Tian Zhu. 2018. The health effects of individual characteristics and environmental factors in China: Evidence from the hierarchical linear model. *Journal of Cleaner Production* **194**, 554-563. [Crossref]
16. Yu Hao, Shuang Liu, Zhi-Nan Lu, Junbing Huang, Mingyuan Zhao. 2018. The impact of environmental pollution on public health expenditure: dynamic panel analysis based on Chinese provincial data. *Environmental Science and Pollution Research* **25**:19, 18853-18865. [Crossref]

17. Ulf Narloch, Mook Bangalore. 2018. The multifaceted relationship between environmental risks and poverty: new insights from Vietnam. *Environment and Development Economics* **23**:3, 298-327. [Crossref]

18. Shuai Shao, Zhihua Tian, Meiting Fan. 2018. Do the rich have stronger willingness to pay for environmental protection? New evidence from a survey in China. *World Development* **105**, 83-94. [Crossref]

19. Tong Liu, Guojun He, Alexis Lau. 2018. Avoidance behavior against air pollution: evidence from online search indices for anti-PM2.5 masks and air filters in Chinese cities. *Environmental Economics and Policy Studies* **20**:2, 325-363. [Crossref]

20. Bofeng Cai, Huanxiu Guo, Libin Cao, Dabo Guan, Hongtao Bai. 2018. Local strategies for China's carbon mitigation: An investigation of Chinese city-level CO2 emissions. *Journal of Cleaner Production* **178**, 890-902. [Crossref]

21. Yan Wang, Hefeng Tong, Jiajun Xu. 2018. Green Transformation: A System Dynamics Model on Endowment, Investment and Employment. *SSRN Electronic Journal* . [Crossref]

22. Shuai Chen, Paulina Oliva, Peng Zhang. 2018. The Effect of Air Pollution on Mental Health: Evidence from China. *SSRN Electronic Journal* . [Crossref]

23. Pietro F. Peretto, Simone Valente. 2018. Growth with Deadly Spillovers. *SSRN Electronic Journal* . [Crossref]

24. Chander Kant. 2018. South Asia/Frontier Long-Term Income Dynamics and Income-Health Relationships. *SSRN Electronic Journal* . [Crossref]

25. Suxia Liu, Yingming Zhu, Kuanqi Du. 2017. The impact of industrial agglomeration on industrial pollutant emission: evidence from China under New Normal. *Clean Technologies and Environmental Policy* **19**:9, 2327-2334. [Crossref]

26. Natacha Raffin, Thomas Seegmuller. 2017. The Cost of Pollution on Longevity, Welfare and Economic Stability. *Environmental and Resource Economics* **68**:3, 683-704. [Crossref]

27. Xiaoyu Chen. 2017. Effect of particulate air pollution on coronary heart disease in China: Evidence from threshold GAM and Bayesian hierarchical model. *Physics and Chemistry of the Earth, Parts A/B/C* **101**, 35-42. [Crossref]

28. Manhong Shen, Yongliang Yang. 2017. The Water Pollution Policy Regime Shift and Boundary Pollution: Evidence from the Change of Water Pollution Levels in China. *Sustainability* **9**:8, 1469. [Crossref]

29. Siqi Zheng, Matthew E. Kahn. 2017. A New Era of Pollution Progress in Urban China?. *Journal of Economic Perspectives* **31**:1, 71-92. [Abstract] [View PDF article] [PDF with links]

30. Hassan El-Ramady, Tarek Alshaal, Mohamed Abowaly, Neama Abdalla, Hussein S. Taha, Abdullah H. Al-Saeedi, Tarek Shalaby, Megahed Amer, Miklós Fári, Éva Domokos-Szabolcsy, Attila Sztrik, József Prokisch, Dirk Selmar, Elizabeth A. H. Pilon Smits, Marinus Pilon. Nanoremediation for Sustainable Crop Production 335-363. [Crossref]

31. Cong Sun, Matthew E. Kahn, Siqi Zheng. 2017. Self-protection investment exacerbates air pollution exposure inequality in urban China. *Ecological Economics* **131**, 468-474. [Crossref]

32. Xiaoyu Chen, Shuai Shao, Zhihua Tian, Zhen Xie, Peng Yin. 2017. Impacts of air pollution and its spatial spillover effect on public health based on China's big data sample. *Journal of Cleaner Production* **142**, 915-925. [Crossref]

33. Ji Qi, Xin Tang, Xican Xi. 2017. The Size Distribution of Firms and Industrial Water Pollution: A Quantitative Analysis of China. *SSRN Electronic Journal* . [Crossref]

34. Shihe Fu, Peng Zhang. 2017. Air Quality and Manufacturing Firm Productivity: Comprehensive Evidence from China. *SSRN Electronic Journal* . [Crossref]

35. Shuai Chen, Paulina Oliva, Peng Zhang. 2017. The Effect of Pollution on Migration: Evidence from China. *SSRN Electronic Journal* . [Crossref]

36. Qin Fan, Stephan J. Goetz, Jiaochen Liang. 2016. The interactive effects of human capital and quality of life on economic growth. *Applied Economics* **48**:53, 5186-5200. [Crossref]

37. Guojun He, Maoyong Fan, Maigeng Zhou. 2016. The effect of air pollution on mortality in China: Evidence from the 2008 Beijing Olympic Games. *Journal of Environmental Economics and Management* **79**, 18-39. [Crossref]

38. Guojun He, Maoyong Fan, Maigeng Zhou. 2015. The Effect of Air Pollution on Mortality in China: Evidence from the 2008 Beijing Olympic Games. *SSRN Electronic Journal* . [Crossref]

39. Guojun He, Maoyong Fan, Maigeng Zhou. 2015. The Effect of Air Pollution on Mortality in China: Evidence from the 2008 Beijing Olympic Games. *SSRN Electronic Journal* . [Crossref]