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ABSTRACT

China’s extremely high levels of urban air, water and greenhouse gas emissions levels pose local and global environmental challenges. China’s urban leaders have substantial influence and discretion over the evolution of economic activity that generates such externalities. This paper examines the political economy of urban leaders’ incentives to tackle pollution issues. Based on a principal-agent framework, we present evidence consistent with the hypothesis that both the central government and the public are placing pressure on China’s urban leaders to mitigate externalities. Such “pro-green” incentives suggest that many of China’s cities could enjoy significant environmental progress in the near future.

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Introduction

China's pollution challenges are well documented. Many cities in China have extremely high air pollution levels. In early 2013, the terrible smog haze pollution in North China caught the world's attention.[1] The PM2.5 concentration in those cities has been two, three, even four times the emergency threshold of 250 μg/m^3 (and up to 40 times levels the WHO considers healthy).[2] Based on an ambient particulate concentration criterion of PM10, twelve of the twenty most polluted cities in the world are located in China (World Bank, 2007b). This pollution has mainly been caused by emissions from the heating and electricity sector (based on coal), and the industrial and transportation sectors.

Electricity demand is soaring in China as China surpassed Japan as the second largest economy in the world at the end of 2009. China's energy consumption accounted for 17.3% of the world's total. The nation's electricity consumption reached roughly 4.5 trillion kilowatt hours in 2011.[3] Given that 80% of China's electricity is produced by coal fired power plants this has led to a huge increase in greenhouse gas emissions.

If China's central and local governments stepped in and mandated credible regulations, then pollution externalities across China's cities could be mitigated. Environmental economists have long argued based on cross-national evidence that there is a "J" curve for regulation such that middle income nations start to implement such regulation which grows more intense as these nations develop from being middle income to being rich (Selden and Song 1995).

As China becomes one of the world's leading economies, it is possible that a similar dynamic could play out there. Such an optimistic, and deterministic, vision of endogenous regulatory adoption as a function of only national per-capita income abstracts away from institutions and incentives as important determinants of whether government officials are "up to the job" of combatting pollution. Yet, leading studies in growth economics have emphasized the fundamental role that institutions

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[1] See http://www.chinadaily.com.cn/china/2013-01/14/content_16115953.htm for more background information.
[2] See http://www.chinafile.com/airpocalypse-now-china-tipping-point. Particles 2.5 microns or less in diameter (PM2.5) are referred to as "fine" particles and are believed to pose greater health risks than larger particles because they can embed deep in people's lungs.
[3] See:
http://www.bloomberg.com/news/2011-01-28/china-s-power-demand-growth-may-slow-to-9-this-year-nea-says.html

play in economic development (Acemoglu and Robinson 2012).

Until recently, neither China's national government officials nor local urban officials prioritized environmental protection. China's central government focused on economic growth with an emphasis on GDP as the key evaluation criterion for local officials' performance (Chen et. al. 2005; Li and Zhou 2005). Local officials thus sought to boost their local economy through attracting dirty industries, but had little incentive to reduce energy consumption or protect the environment in their own jurisdictions since such actions did not help their political career (Wu et. al. 2013).

The Chinese central government creates a "tournament competition" among local mayors by promoting or demoting them on the basis of relative performance (Bo 1996; Wu 2010). Such a tournament raises the possibility that the central government can incentivize urban officials to devote more attention to environmental challenges. In recent years the central government has been changing the performance evaluation criteria for local officials from purely output-based to including more "greenness" in the performance vector (Landry 2008). Below we discuss why the central government changed its focus on GDP growth to an objective function that also includes environmental goals. The driving forces were both a desire to improve the people's quality of life and a desire to establish legitimacy in the public's mind to help retain political power (Wang 2013).

Local residents provide a second source of pressure on urban mayors. In democracies, voters have the ability to hold the politicians accountable for their policy choices (Hårsman and Quigley, 2010; List, 2006). While China's urbanites do not directly vote, they have alternative strategies for expressing their views. As the new urban cohorts become richer and more educated, they are increasingly likely to value safety and greenness and thus their demand for information and political accountability will also rise. Improvements in information technology have reduced the cost of information acquisition. Examples include the Internet media, micro blogs (*weibo*, the Chinese version of Twitter)[4], instant phone messages, and more liberated local newspapers. Access to this information has allowed local people to be better informed about pollution challenges. The salience of this news allows them to overcome potential free rider issues and to unite to express their concerns and displeasure with current urban quality of life. Since social stability is an important target when the State evaluates local officials, those local officials are keen to address

[4] The micro blog, as a nascent web application emerged in 2009, had 250 million users by the end of 2011.

their people's demand for a cleaner environment.

This paper uses unique city level panel data to test a variety of predictions based on a principal-agent model of regional environmental enforcement. In this paper, the urban leaders are the agents. They have private information over the key local firms' pollution emissions into the air, ground water and underground water, and they have private information about their own environmental regulation enforcement efforts in their cities. In the absence of highly powered incentives, local government officials have little incentive to enforce such regulations in their own jurisdictions if that does not help their political career. In the past, when the central government had a news monopoly, even environmental disasters might not have been widely known. In the absence of such information, industrial malfeasance would be more likely to take place as firms would under-invest in precautions.

We hypothesize that relative to the past, urban mayors in China now face political pressure from the central government and the local public who are each demanding environmental progress. In a metaphorical sense, the mayors are "sandwiched" by these two different pressure groups and thus have less discretion than they had in the recent past.

We use data sets of prefecture-level city mayors, energy intensity and ambient particulate matter (PM10) indicators within our study period (2004-2009) to test whether there is an association between environmental performance and an urban leader's probability of being promoted? We also test whether objective measures of urban resident concern are associated with environmental progress. We present evidence consistent with the hypothesis that both the central government's regime shift and urban households' rising demand for greenness are contributing to local politicians' accountability for their city's energy and environmental performance.

This paper contributes to a nascent empirical literature on the role that political leadership plays in determining government priorities over public goods provision versus economic growth. Jones and Olken (2005) document the role that national leaders play in affecting macroeconomic growth. List and Sturm (2006) documents using evidence on U.S governors who due to term limits cannot seek to run again that the priorities change. Ferreira and Gyourko (2009) document differentials in U.S mayor policies over taxes，spending and public sector employment. This literature suggests that urban leader differences in observable attributes predict their choices and policy outcomes. Below, we will use demographic information about Chinese mayors to test whether attributes such as their education play a role in determining the city's pollution dynamics.

The rest of the paper is organized in five sections. Section 2 describes the political economy of environmental regulation in China, especially the role of promotion criteria. Section 3 discusses our data creation as we construct several indices to reflect Chinese urbanites' concern intensity over pollution, and test whether those indices can effectively capture the spatial variation of this concern. Section 4 presents the empirical results measuring local governments' actions and outcomes. Section 5 concludes.

2. The Principal-Agent Problem in Mitigating China's Urban Pollution Problems

2.1 Nudges from the State

China has a strong one-party central government, but hundreds of local governments act as competing enterprises. The State Council appoints the governors of provinces, municipalities, and some major cities (so-called "provincial-level" and "vice-provincial" cities) directly. Provincial governments appoint the governors of prefecture-level cities. How to select and reward subordinate officials is central to the effective governance of every large organization. The selection and promotion process is performed by the upper-level CCP (China's Communist Party) Committee's personnel department, which is a key sector in the upper-level government. This process is quite complicated, including performance evaluation with objective and quantitative targets, individual interview, and qualitative assessment of capacity and potential. Therefore, the promotion rule cannot be written out as a simple function. Quantitative performance evaluation is becoming more important because it is relatively easy to be performed, and it is regarded by the local leaders as a fair way to compare their performance with their peers. The State also wants to push local governments to achieve its goals.

In the past, GDP growth was the main criteria used by upper-level governments in evaluating the performance of lower-level officials' performance and deciding whether to promote them to higher positions. Very recently, sustainability and social stability are included in the promotion criteria. Below we discuss the reasons for this regime switch.

The Chinese State has established a number of notable targets for energy efficiency and pollution reduction. Specific energy efficiency and pollution reduction targets were clearly set and included in the tenth, eleventh and twelfth “Five-Year Plan” (2001-2005, 2006-2010, 2011-2015 FYP, respectively). At the Copenhagen Climate Summit in 2009, China pledged to achieve a carbon intensity reduction of 40-45% by 2020 (Department of Climate Change, NDRC, 2010). In the tenth FYP, the target was set that major water and air pollutants should decrease by 10 percent over the five-year period. In the eleventh FYP, the target was that major pollutants such as COD and SO_2 to decrease by 10 percent each year from the 2005 level; Energy consumption per unit of GDP to decline by about 20% from the 2005 level.

There are several motivations behind the Chinese central government’s ambitious shift to emphasize pollution reduction and climate change mitigation goals. First, domestic energy security concerns have risen on the central government’s agenda as a result of electricity shortages and rapidly rising energy consumption. Second, the central government believes that the rest of the world is embracing the low-carbon energy agenda has created a market imperative for China to become a technological and economic leader in this nascent field (Boyd 2012). Third, the central government may be concerned about the direct productivity loss and the disamenity effects caused by pollution exposure. Another possible explanation is that the central government seeks "legitimacy" with the Chinese people and also in the international arena, and making a commitment to pursuing environmental goals is one way to credibly signal to both domestic constituents and international actors that China is an international leader and that the Communist Party leadership cares about its own people (Wang 2013). This suggests that environmental protection is a type of public relations campaign to boost popular support and to reduce the risk of social instability.

Including greenness targets in the performance evaluation and promotion criteria of local government leaders is the State’s key approach to address the principal-agent problem in pursuing its sustainable development strategy. Since the 11th FYP, the State has started to mobilize local government via the application of the target responsibility system (TRS) of energy conservation and pollution reduction, which is a top-down policy implementation mechanism based on China’s prevalent top-down pressure transfer political hierarchy (Qi, 2013). TRS involves four major steps:

disaggregating targets, signing target responsibility contracts, accounting and monitoring energy consumption, and assessing target performance. For the first step, the central government disaggregated the total energy conservation and pollution reduction targets to provincial governments, and then provincial governments disaggregate their targets to municipal governments. The target responsibility contract is normally signed between the top officials of the upper and lower level governments.

Assessment and evaluation of target responsibility is a quantitative exercise. The energy conservation target, with the decline of energy intensity (*EI*, energy consumption per unit of GDP) as the major indicator, accounts for 40 points out of the total 100 points. The accounting system of this EI decline indicator was set up by the State Council. The other 60 points include many items, ranging from regularly reporting energy consumption numbers to upper level governments; investing in energy conservation and pollution reduction infrastructures, to effectively implementing environmental regulations. The assessment result is used in the performance evaluation of local leaders.[5]

A potential problem of the TRS is that the main targets are not closely linked to environmental outcomes that have significant impacts on the public's health and quality of life. Instead, they are linked to the accounting indicators such as energy intensity and environmental infrastructure investment. One possible reason is that those accounting indicators are easier to measure. Credit for pollution reduction might be granted, for example, for the construction of a waste gas treatment plant or installation of pollution control technology in a power plant. Therefore local officials are incentivized to invest in environmental infrastructure and pollution control technology. With insufficient monitoring, there was much less focus on whether these investments are operated properly such that they actually reduce pollution. It was reported that factories adjusted pollution control equipment to report false data, treatment plants were left idle, local governments forced emergency shutdowns of electricity to local public services to meet energy efficiency targets, and so on (Wang, 2013).

2.2 Nudges from the urban public

While the central government has set performance standards based on criteria

[5] See the requirement in "Interim Procedures for Comprehensive Assessment and Evaluation of Local Leading Groups and Leading Cadre of CPC and Governments Embodying the Scientific Outlook on Development", published in September 2006.

such as the number of pollution control facilities, the urban public has different priorities. They care about clean air and water. In the past, the public faced greater information costs concerning the environmental challenges their city faced. The State and local governments monopolized the media – newspaper, radio and television. When a one party state controls information releases it may systematically choose to release information that helps it to achieve its political goals and may suppress negative information (Liu and Yang 2009; Guan et al., 2012).

With the rise of the modern media and IT technologies such as blogs, micro blogs, instant phone messages, China's government has been losing its information disclosure monopoly. Local newspapers are also more liberalized. To attract readers, they report negative news such as pollution, corruption and land seize disputes. Improvement in remote sensing and cheaper pollution monitors has allowed external research teams to measure and distribute information about China's pollution levels (Zhang et. al. 2007).

Recent research set in the US, India, Brazil, and Indonesia highlight the power of the media and information disclosure to mitigate classic principal-agent problems and to nudge government officials to supply public goods (Gentzkow, Matthew and Shapiro, 2010; Besley and Burgess 2002; Ferraz and Finan 2008; Pargal and Wheeler 1996). But those studies are all conducted in democracies. We are interested in whether the rising of information transparency in Chinese cities plays a similar role. The recent upsurge of environmental mass incidents provides some clues of this. In those mass incidents, the modern media helps to trigger a snowball effect, and this allows the public to co-ordinate and overcome transaction costs to unite together to pretest against pollution accidents. Representative examples include the Xiamen PX protest in 2007[6], Dalian PX protest in 2011[7], Shifang MoCu project protest in 2012[8], and Qidong protest on the paper mill's pollution discharge into the sea in 2012[9]. According to statistics, the number of mass incidents caused by pollution increased at an annual rate of 29% (Tong, 2007). Those events significantly threatened social

[6] http://news.bbc.co.uk/2/hi/asia-pacific/7195434.stm

[7] In August 2011, messages were widely spread through micro blogs, blogs, Twitter and other internet forums that a PX (paraxylene) chemical factory (a joint venture between the city and a private company) built in Dalian city was at high risk to flood the town with the highly toxic chemical. Twelve thousand Dalian residents organized a peaceful public protest in Dalian's People's Square on August 14, demanding the factory to be immediately shut down and relocated, and that the details about the investigation into the factory should be made public. The Dalian government forbade the factory from opening. See http://www.bbc.co.uk/news/world-asia-pacific-14520438

[8] http://www.nytimes.com/2012/07/05/world/asia/chinese-officials-cancel-plant-project-amid-protests.html?_r=0

[9] http://www.nytimes.com/2012/07/29/world/asia/after-protests-in-qidong-china-plans-for-water-discharge-plant-are-abandoned.html

stability, which is now another key target when evaluating local officials' performance. Therefore mayors are becoming more concerned about local people's concern about environmental quality and local quality of life.

2.3 Empirical Hypotheses

Based on the above discussion, we focus on testing four hypotheses related to the correlates of urban leaders pursuing policies that bring about environmental progress:

H1: Local officials are more likely to be promoted if their city experiences environmental progress.

H2: Public concern over urban pollution varies across space. Those regions (province/city) facing stronger demand for environmental quality and with higher media openness have higher public concern intensity.

H3: The attributes of the local leaders are associated with environmental outcomes. Cities with higher educated leaders experience greater energy and environmental progress.

H4: Cities facing more pressure from the public will engage in greater energy conservation and environmental protection so that they exhibit a different Environmental Kuznets Curve shape.

3. Measuring Pollution-Mitigation Incentives from the State and the Public

3.1 The inclusion of greenness in local officials' promotion criteria

In this section we test hypothesis #1 and #2. First, we test whether energy conservation and pollution reduction indicators are reflected in city mayors' promotion criteria. We select three energy/environment indicators. One is the energy intensity measure, which is the top indicator in TRS. Energy intensity of urban productivity (*EI*) is measured as "energy consumption per GDP dollar" (ton standard coal per 10,000 RMB) by city/year (Equation (1)).

$$EI_{it} = \frac{Energy_{it}}{GDP_{it}} = \frac{\sum_{j}^{J}(GDP_{ijt} \cdot EI_{jt})}{GDP_{it}} = \frac{\sum_{j}^{J}(GDP_{ijt} \cdot \frac{Energy_{jt}}{GDP_{jt}})}{GDP_{it}} \quad (1)$$

Where subscript *i* represents city; *t* represents year; and *j* represents industry. The energy consumption and GDP data are collected from the "China City Statistical Yearbook". Figure 1 shows the energy intensity values for the 86 cities in our sample in 2009. The energy intensity had decreased for many cities during this period. The EI variable measures a city's industry composition effect. If a city's industrial composition shifts towards industries that use little energy then the EI will decline over time.

*** Insert Figure 1 about here ***

We have collected two indicators on air pollution. One is an "accounting" indicator – annual expenditure on waste gas treatment facilities per GDP dollar (*FACILITY_EXP*); and the other one is the "real feeling" indicator – the ambient particulate concentration in the air (*PM10*).[10] The first variable measures local governments' effort in providing air pollution mitigation facilities, which help them to gain some credit in the TRS. For the second measure, we first collect the API (air pollution index) of each city by week from the website of the Ministry of Environmental Protection, People's Republic of China[11], and then calculate the average PM10 concentration (mg/m^3) by city by year (*PM10*). Since people are more sensitive to severely polluted days, we also construct the variable $PM10_{p75}$ which stands for the 75 percentile value of PM10 concentration by city/year. Figure 2 shows the PM10 values for the 86 cities in 2004 and 2009. Again, many cities enjoyed air quality improvement during this period.

*** Insert Figure 2 about here ***

[10] Total suspended particles (TSP) measures the mass concentration of particulate matter in the air. Within TSP, PM_{10} stands for particles with a diameter of 10 micrometers or less. Particulates that are ten micrometers or greater are filtered and generally do not enter the lungs. Particulates smaller than ten micrometers are likely to enter the lungs.
[11] http://datacenter.mep.gov.cn/.

A city has two leaders – the mayor and the CCP secretary. Our local official data set is by city/year and it contains the mayor's and the CCP secretary's information of age, gender, education attainment, starting year of his/her term on this position, the previous position and the next position. The data was collected from The China Yearbook of Municipalities, provincial yearbooks and reports from the mass media.

By law, the mayor is the executive officer of the municipal (city) government. At the same time, the law also says that the mayor is under the guidance of the city communist party committee of which the party secretary is the head. In practice, the division of labor is that the party secretary is in charge of the personnel and other political duties, while the mayor is in charge of the daily operation of the government for which economic growth is a top priority and now energy conservation and environmental protection are also addressed.[12] Since the determinants of promotion may differ between party secretaries and mayors, we run the probit model for mayors and secretaries separately. Here we mainly discuss the regression results of the mayor's promotion equation, and place those of the city's CCP secretary in the Appendix.

As economic growth is well known to be a prime determinant for promotion (Li and Zhou, 2005), we test that if the upper level government has begun to also include proxies for greenness into the promotion evaluation system.

$$\begin{aligned} Promotion_{it} &= \beta_0 + \beta_1 \cdot GDP\_Growth_{it} + \boldsymbol{\beta_2} \cdot \mathbf{GREEN}_{it} + \boldsymbol{\beta_3} \cdot \mathbf{Z}_{it} \\ &+ City\ \ fixed\ effects + Year\ \ fixed\ effects + \delta_{it} \end{aligned} \tag{2}$$

In Equation (2) the unit of analysis is city/year. The dependent variable is a dummy indicating whether the mayor of city *i* gets promoted or not in year *t*, which equals 1 if the officer moves to a higher level (including a mayor promoted to be a CCP secretary in the same or another city), and equals 0 if he or she remains on the current position, or moves to another position in the same or lower level, or retires. "Abnormal" changes, e.g. death, arrest due to corruption, etc., are excluded from the sample. We include GDP growth which is measured as the difference between the average annual GDP growth during this mayor/secretary's term (till that year) and that

[12] In most cities, the party secretary is clearly the No. 1 leader because key decisions are made in the party committee. However, his power is checked by the mayor because in theory the executive orders should be delivered through the mayor. In the end, the party secretary and the mayor share power in a city. To the extent that the mayor has to rely on the bureaucracy to manage the economy, his contribution to local economic growth is tied to the party secretary's efforts to select more capable subordinates. The interaction between the party secretary and the mayor takes many forms and the pattern of their contributions to local economic growth cannot be readily parameterized (Yao and Zhang, 2012).

during his or her predecessor's tenure (Wu et. al. 2013). Our focus is the green indicators (**GREEN**) – *EI* (the key indicator in the TRS), *FACILITY_EXP* (the "accounting" indicator of pollution mitigation effort), *PM10* and $PM10_{p75}$ ("real feeling" pollution indicators) measures. *EI*, *PM10* and $PM10_{p75}$ are measured in annual percentage decreases.[13] The annual percentage decrease in EI is a commonly-used quantitate target when evaluating local officials' performance. *FACILITY_EXP* is an annual flow variable so we lag this variable to mitigate concerns about reverse causality.

Personal attributes (age, educational attainment and the term length till that year) of the officer are also included in the model. Year fixed effects are included. To address possible endogeneity concerns with estimating equation (2), we include city fixed effects to control for time invariant city attributes such as natural endowments (lake, river, coal, etc.) and pollution incidents, may affect both the mayor's promotion odds and the city's environmental progress.[14]

Our empirical study is based on data for 86 cities from 2004 to 2009. Among these 86 cities, there are 35 major cities (4 municipalities plus 31 provincial capital cities) and 51 medium and small-sized cities. We also collect the data of city attributes from China Statistics Yearbooks and China City Yearbooks, including GDP per capita (*GDPPC*), city population (*POP*), annual rainfall in year 1999 (*RAIN*, in mm), temperature discomfort index in year 1999 (See Zheng, Fu and Liu (2009) for the construction of this index) (*TEMP*). The variable definitions and descriptive statistics are listed in Table 1.

*** Insert Table 1 about here ***

Table 2 reports the results of mayors' promotion equation regressions. Our results

[13] Since we do not have energy and air pollution data before 2003, we are unable to construct the variables measuring EI/PM10 declines by officer terms as GDP.

[14] In estimating equation (2), we are implicitly assuming that unobserved attributes of mayor quality are uncorrelated with the key explanatory variables. We acknowledge the possibility that a capable mayor may be sent to a dirty city to help cleaning that city, or to a clean city with big potential to grow. We only have a limited number of mayors' attributes (age, years on position and education attainment). Therefore omitted mayor attributes may also correlated with both the mayor's promotion probability and his effort in reducing pollution (as well as booming the economy).

indicate that the relative GDP growth rate (comparing to the previous mayor) is the most important determinant of a mayor' s promotion. This variable (*GDP_Growth_M*) is statistically significant at 1% level in all regressions with city and year fixed effects. Column (1) is the baseline model. In column (2) we augment the regression by including the PM10 decline measure. It contributes to the promotion probability and the effect is statistically significant at the 10% level. In column (3) we replace this variable with the improvement in air quality in severely polluted days ($PM10_{p75}$). This variable has a larger positive effect (statistically significant at the 5% level) on the promotion probability, indicating that air quality improvement in the most polluted days helps the mayor in his/her performance evaluation. In column (4) we replace the air quality measure to the energy intensity (*EI*) decline measure. It is positive and statistically significant at the 10% level. In column (5) we change to the lagged waste gas treatment facility expenditure (*FACILITY_EXP*), which is significantly positive at 1% level. Based on the coefficients reported in columns (1) to (5), we find that a 1% decrease in the PM10 rate, and a 1% decrease in the energy intensity rate, and a 1% increase in waste gas treatment facility expenditure will increase the mayors' promotion odds by 0.34%, 0.32% and 1%, respectively. In column (6), we include the three green indicators (*PM10*, *EI* and *FACILITY_EXP*) together in the same regression. The facility variable is significantly positive at 1% level and the other two are statistically significant at the 10% level. The joint F-test shows that the three variables are jointly significant at the 1% level. In column (7) we replace *PM10* with $PM10_{p75}$. The above results support the hypothesis that energy/environmental improvements are positively associated with a mayor's promotion odds.[15]

*** Insert Table 2 about here ***

The highly significant facility expenditure variable but less significant air quality measures supports the claim that the promotion criteria emphasize "accounting" measures over the more relevant public health variables such as PM10. In fact, *PM10* and *FACILITY_EXP* have a very weak correlation of 0.02 during our study period.[16]

[15] We acknowledge the possibility that environmental progress is positively correlated with other unobserved improvements in a city's quality of life. In this case, we would over-attribute the mayor's promotion to environmental progress when instead the true mechanism is improved overall quality of life.

[16] In results that are available on request, we have re-estimated equation (2) for a subset of 35 major cities and estimated this equation for a later period (2006-2009). We sought to test for heterogeneity with respect to the correlation between urban environmental performance and promotion probabilities. We reject the hypothesis that

3.2 Measuring public concern intensity over pollution and its spatial variation

We construct two indices to reflect urban residents' concern intensity over environmental issues. The first is the Google Insights index based on the internet search intensity of the key word – "environmental pollution (*huan jing wu ran*)", as a measure of public concern intensity on internet. Google Insights[17] is a publically available online tool for tracking aggregate Google search intensity over time for specific geographic areas.[18] Recent research (Kahn and Kotchen 2011) shows that Google search terms are a powerful tool to predict trends in U.S concern about global warming and are negatively correlated with state's monthly unemployment rate. Google Insights can report a search intensity index of a specific key word by geographic area (in the Chinese version of Google Insights, the geographic unit is province) during a time period specified. Here, we construct this public concern index (*PCI_1*) by province/year (Figure 3). Provinces with heavy industrial pollution (such as the northeast region, Shan'xi, Chongqing and Yunan) have higher index values.

The second index aims to measure the frequency of pollution-related articles reported in a city's local newspapers. We search for the same key word "environmental pollution (*huan jing wu ran*)" in Google search and set the search criteria to be the articles published in a city's major local newspapers in a year.[19] We count the number of entries and divide this number by the total circulation of those local newspapers in each year to obtain a standardized index by city/year. Once published, newspapers articles will be cited by web media sites and appear on those sites. This index captures the total concern intensity based on the original articles published in local newspapers, and the webpages citing those articles. Figure 3 shows the spatial variation of this index across cities.

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in larger cities that there is a stronger correlation between environmental performance and promotion. To our surprise, we also reject the hypothesis that this association has grown larger in recent years (we compare the estimate of β_2 in 2004-2005 to an estimate of this coefficient between 2006 and 2009). Table A1 in the Appendix report the same regression results for cities' CCP secretaries. In Table A1, the relative GDP growth rate is also the most important determinant of party secretaries' promotion odds. However, neither of the green indicators show significant contribution to party secretaries' promotion probability. They are also not jointly significant.

[17] Google Insights is available at http://www.google.com/insights/search/#.

[18] Baidu is a local search engine that is widely used in China. It started to provide a similar search intensity index from June 2006. We do not use the Baidu index due to two reasons. First, the availability of this Baidu index cannot cover our study period; second, some have claimed that the Baidu search engine manipulates the relative sorting order of some search outcomes.

[19] This specific search cannot be done in Google Insights so we use Google Search.

*** Insert Figure 3 about here ***

We estimate equation (3) to explore the spatial and temporal variations in the two indices. Our hypothesis is that the public concern intensity about pollution will be higher if urban households' demand for environmental quality is stronger, the city (province) has a higher level media openness level, and the city (province) has poorer environmental condition. We estimate:

$$\log(PCI_{it}) = \alpha_0 + \alpha_1 \cdot \log(DIS\_HK_i) + \alpha_2 \cdot \log(INTERNET_{it}) + \alpha_3 \cdot \log(GDPPC_{it}) + \alpha_4 \cdot EDU_{it} + \alpha_5 \cdot ACC\_NUM_{it} + \alpha_6 \cdot \log(POP) + region\ \ fixed\ effects + year\ \ fixed\ effects + \varepsilon_{it} \quad (3)$$

Due to data availability, the unit of analysis is province/year for the first index (*PCI_1*) and city/year for the second index (*PCI_2*). In Equation (2), *DIS_HK* is city/province *i*'s distance to Hong Kong. Those places close to Hong Kong are exposed to a relatively freer media environment. People there can watch Hong Kong TV, have a better access to Hong Kong newspapers and publications, and also have some contacts with Hong Kong people. Therefore they have a better understanding of civil society, how the media works and they can do. This effect diminishes fast as the distance to Hong Kong increases so we measure the distance in logarithm term. *INTERNET* is the number of internet users in city/province *i* in year *t*. This measure should be positively correlated with media openness. Cities/provinces with higher *GDPPC* (per capita GDP) and *EDU* (average years to schooling) are expected to face a stronger demand for environmental amenities. People in the provinces with more pollution accidents (*ACC_NUM*, this variable is only available at province level) may have higher concern intensity over environmental issues. We control for a city/province's population, city/province fixed effects and year fixed effects.

Table 3 reports the regression results for Equation (3). The dependent variable in column (1) is log(*PCI_1*). Provinces close to Hong Kong and with more internet users have higher public concern intensity over pollution. These two variables are both statistically significant. Richer provinces have higher index values. People in the provinces with worse air quality (higher PM10) have significantly higher public concern intensity on "environmental pollution". In column (2), the dependent variable is log(*PCI_2*). We find that distance to Hong Kong and the number of Internet users both significantly contribute to higher public concern intensity over pollution in local newspapers. All else equal, a one percent increase in the distance from Hong Kong is associated with 1.4 and 0.5 percent increase in *PCI_1* and *PCI_2*, respectively. The elasticities of *PCI_1* and *PCI_2* with respect to the number of IT users are 1.1 and 0.2, respectively. High levels of air pollution triggers more attention. Cities with higher human capital (*EDU*) have significantly higher public concern over pollution. One more year in local residents' average years of schooling contributes to a 26.5% higher value of *PCI_2*.

*** Insert Table 3 about here ***

4. Local Officials' Effort and Environmental Outcomes

In this section we test our hypothesis #3 and #4. We investigate whether the nudges from the State and the public affect a city's energy consumption and environmental outcomes.

4.1 Local officials' combatting-pollution actions and the role of leadership

A distinctive feature in Chinese cities is that local governments have a "visible" hand in influencing economic activity. That is why the TRS places local governments at the center of policy implementation. City leaders face trade-offs between economic growth and environmental quality. They can use cheap land and favorable tax deduction policies to attract the firms that can generate high GDP output, high tax revenues and more job opportunities, but those firms may be energy-intensive ones.[20] If city leaders want to achieve pollution control requirement, they can also shut down heavily-polluted factories, and force those factories to leave (Witte et. al. 2009). In this way the city will lose tax revenue and certain types of jobs. In addition, city leaders have a powerful control over the big SOE energy-intensive firms within their jurisdictions. Those SOE firms are also included in the TRS. City leaders will sign target responsibility contracts with those firms' managers, and the evaluation of the

[20] For example, in Zhejiang Province's "new technology zones", the government spent $96,000 US dollars per acre on average to provide basic infrastructure for the industrial land, but the average sale price of such industrial land to firms was only $83,000 US dollars per acre. Half of the industrial land parcels were sold at a price less than 50% of the infrastructure construction cost. In some inland provinces, industrial land is sold at a zero price (see http://www.snzg.cn/article/2011/0318/article_22780.html).

managers' performance on the energy and environmental dimensions will affect those managers' career (Qi, 2013).

In Table 4, we examine if the leaders in those cities with higher public concern intensity put more effort in pollution mitigation activities. The dependent variable of column (1) and (2) is log(*FACILITY_EXP*). On the right-hand side, we include the one-year lagged public concern indices. Population and GDP per capita are controlled for. Province fixed effects (or city fixed effects) are also included. For those provinces with lagged higher *PCI_1* (or cities with lagged *PCI_2* growth), they experience significantly larger increase in waste gas treatment facility expenditure. In column (3) and (4), the dependent variable is log(*EI*). The public concern indices have weaker effects on energy intensity though the signs are intuitive.

*** Insert Table 4 about here ***

We examine the role of political leadership in determining energy/environmental actions and outcomes. Here we focus on city leaders' human capital level, measured by years to schooling (*EDU_MAYOR*, *EDU_SECRETARY*). Higher-educated leaders may devote more efforts in protecting the environment, and thus their cities may benefit from their leadership and enjoy an aggressive environmental/energy progress.

In a similar spirit as Jones and Olken (2005), who use the deaths of leaders while in office as a source of exogenous variation in leadership, and ask whether these plausibly exogenous leadership transitions are associated with shifts in country growth rates, we exploit leadership transitions across China's cities. For each city *i*, if there is a leadership transition for the mayor (or CCP secretary) position during our study period, we calculate the change of air pollution, energy intensity and waste gas treatment facility expenditure between the last year of the new leader (mayor II) and the last year of the previous leader (mayor I), and see if this change is correlated with the human capital differential between the former and the new leader (Equation (4)).

$$\begin{aligned}\Delta_{i,mayorII-mayorI}PM10 = \phi_1 \cdot \Delta_{i,mayorII-mayorI}EDU + \phi_2 \cdot \Delta_{i,mayorII-mayorI}POP \\ + \phi_3 \cdot Time\_length_{i,mayorII-mayorI} + \phi_4 \cdot PM10_{i,mayorI} + \varepsilon_{it}\end{aligned} \tag{4}$$

Table 5 reports the regression results for the mayor transitions. We include the time length between the two time points to control for the time trend in the dependent variable. City population change is also controlled for. We find that if a new mayor has a higher educational attainment than the former mayor, the city enjoys a significant air quality improvement. A one year increase in the mayor's years of schooling is associated with about a 2% decrease in the PM10 concentration.[21]

*** Insert Table 5 about here ***

4.2 Do public concern and political leadership influence the shape of the Environmental Kuznets Curve

Building on the influential Grossman and Krueger (1995) study of the "Environmental Kuznets Curve" (EKC), an entire subfield of environmental economics has emerged that focuses on this "inverse-U" association between national per-capita income and pollution (Andreoni and Levinson 2001, Stokey 1998). In past research, we have estimated Environmental Kuznets Curve across China's cities (see Zheng, Kahn and Liu 2010). We examine how the shape of the EKC and in particular the GDP "turning point" varies as a function of city attributes and the city's political leader's attribute. We expect that those cities with higher public concern intensity on pollution or higher human capital, or those cities with higher-educated mayor/secretary can reach the turning point at a relatively low income level.

Harbaugh, Levinson and Wilson (2002) suggests that the EKC is a fragile empirical result, and the pollution-income relationship is quite sensitive to functional forms (the order of the income polynomial function), the variable form, additional covariates, and the sample composition. Here we do not embrace the EKC as a unique "law of physics" that offers a deterministic law of motion for pollution in every city at every point in time. Instead, we borrow the idea of EKC and estimate the gradients of energy intensity and air quality with respect to GDP per capita (see equation (5) below). We let the data itself tell the best order of the polynomial expression of *GDPPC* and the form of this variable (in logarithm or not) to produce the highest R^2. City population, temperature index, rainfall are included as controls. Year fixed effects are also included.

[21] The education background of CCP secretaries does not show any significant effect on the city's energy and environmental progress (Table A2 in the Appendix).

$$\log(Y_{it}) = \eta_0 + \sum_{j=0}^{J}\eta_{1j} \cdot GDPPC_{it}^{j} + \mathbf{\eta_2} \cdot \mathbf{X_{it}} + Year\ \ fixed\ effects + \xi_{it} \tag{5}$$

Where, *Y* represents *EI* or *PM10*. City leaders in urban China have stronger power than their counterparts in the US in influencing their cities' industrial composition. They use cheap land and big tax reduction to attract those firms they favor, and also shut down or move those firms they dislike. City leaders' "visible" hand will reinforce this inverse U relationship between energy intensity and per capita GDP. Our data also tells us that for *EI-GDPPC* relationship, including the level and quadratic terms of *GDPPC* as explanatory variables generates the best fit of the regression.

Table 6 reports the baseline regression results of estimating equation (5). Standard errors are clustered by city. Column (1) and (2) are trend regressions for *PM10* and *EI*. We only control for city population and examine the coefficients of year dummies. We can see that, for the average city, air pollution (PM10) has been sharply declining since 2006 (the beginning of the 11^{th} FYP), and energy intensity's decline followed since 2007. In column (3), after controlling for city population, rainfall and temperature index, there is a clear inverted-U relationship between *EI* and *GDPPC*. The turning point is about 69.1 thousand Yuan (8,324 US dollars, in 2003 constant price[22]). When estimating the *PM10* gradient with respect to GDP per capita (column (4)), we include the level, quadratic and cubic terms of *GDPPC* to achieve a better fit of goodness. The result shows an S-shape of the PM10-GDP path.[23] Those cities that already have passed the turning point and enter the declining part on the right of that point face a bright future in air quality improvement. The peak point is about 40.7 thousand Yuan (4,900 US dollars, in 2003 constant price) per capita. Figure 4 and Figure 5 plot all the cities on the predicted inverted-U shape of the EI-GDP curve, and the S-shape of the PM10-GDP curve.[24]

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[22] \$1=RMB8.3, in 2003.

[23] Harbaugh, Levinson and Wilson (2002) also find such an "S" shape relationship for sulfur dioxide and GDP per capita in their cross-country study.

[24] All other independent variables are set at their mean values.

*** Insert Figure 4 about here ***

*** Insert Figure 5 about here ***

*** Insert Table 6 about here ***

We compare the turning points of the curves for different city sub-groups based on the city's human capital level, public concern about environmental issues (as revealed by our Google indices discuss above) and the mayor's educational attainment. In Table 7, we report estimates of a version of equation (5) where we run separate EKC regressions for subsets of the data. We hypothesize that cities with more educated citizens, more concerned citizens, and more educated mayors are likely to have an earlier per-capita income EKC turning point than other cities.

We use the median value of each public concern index to divide the city sample into two subsamples. Cities with higher public concern intensity over pollution (*PCI_1* or *PCI_2*) do have earlier turning points for both the energy intensity and the PM10 curves (column (1) - (4)). In columns (5) and (6), we identify the subset of cities whose pollution concern indices is higher than the median for both indices (PCI_1 and PCI_2). These high concern cities have much earlier per-capita income turning points for both greenness indicators (see columns (5) and (6)). Cities with higher human capital have a stronger demand for quality of life, and we observe those cities have an earlier turning point for both EI and PM10's gradients with respect to GDP (column (7) and (8)). These patterns support the optimistic hypothesis that stronger civil society and public participation will help China to achieve higher energy efficiency and a cleaner environment. As shown in columns (9) and (10), cities with higher-educated mayors have earlier turning points in their EI and PM10 gradients with respect to GDP. Table A2 (and Table 7's columns (11) and (12) indicates that this correlation does not exist for CCP secretaries.

*** Insert Table 7 about here ***

4. Conclusions

China's urban environmental challenges are well known. While acknowledging the serious challenges that China's amazing growth has posed for its own environmental quality and for global greenhouse gas emissions, this paper has examined the urban political economy of why there are reasons to be optimistic about future externality mitigation progress.

Our study shows early evidence that the state and the public opinion are both nudging local governments for pursuing greenness, and this push has generated desirable outcomes in Chinese cities. We find that energy and environmental targets have begun to be reflected in city mayors' promotion criteria. The power of media and information disclosure helps to clean Chinese cities. Cities with higher human capital and higher public concern about environmental issues have earlier EKC per-capita income turning points for energy intensity and particulate matter. Higher-educated city leaders have a stronger "green" push. Our results indicate that China's layers of government and the general public form a "sandwich" that will contribute to increased environmental sustainability.

Such environmental progress is likely to translate into improvements in the urban standard of living in China and to mitigate a paradox uncovered by Easterlin et. al.'s (2012) work;

"Despite its unprecedented growth in output per capita in the last two decades, …, there is no evidence of an increase in life satisfaction of the magnitude that might have been expected to result from the fourfold improvement in the level of per capita consumption that has occurred."

The rise of China's "green cities" would directly improve quality of life for hundreds of millions of people. This optimistic view hinges on rising middle class demand for quality of life, increased information transparency that encourages the accountability of governments and firms, and the inclusion of environmental indicators that have a direct impact on urban quality of life in the local politicians' performance criteria.

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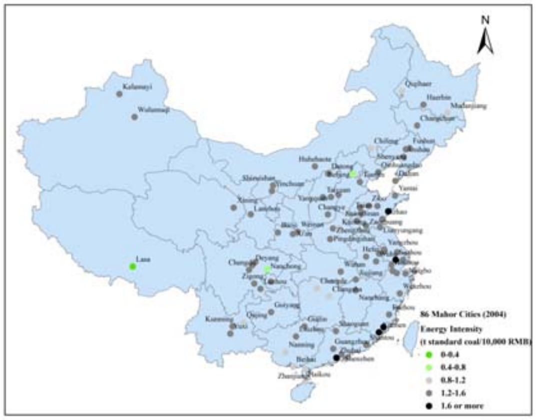
Figure 1 Energy Intensity in 86 Chinese Cities in 2004 and 2009



Energy Intensity in 86 Cities (2004)

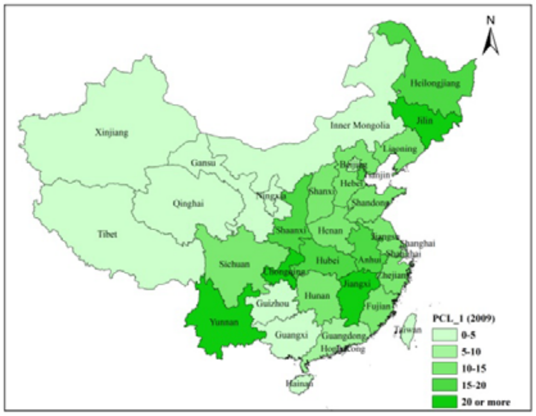
Energy Intensity in 86 Cities (2009)

Figure 2 PM10 in 86 Chinese Cities in 2004 and 2009

Air Quality (PM10) in 86 cities (2004)

Air Quality (PM10) in 86 cities (2009)

Figure 3 Google Insights Index and Google Search Index of Public Concern Intensity on Environmental Pollution (2009)



Google Insights Index of "Environmental Pollution" (*PCI_1*)

Google Search Index of "Environmental Pollution" (*PCI_2*)

Figure 4 Energy Intensity Gradient with Respect to GDP Per Capita (2004-2009)

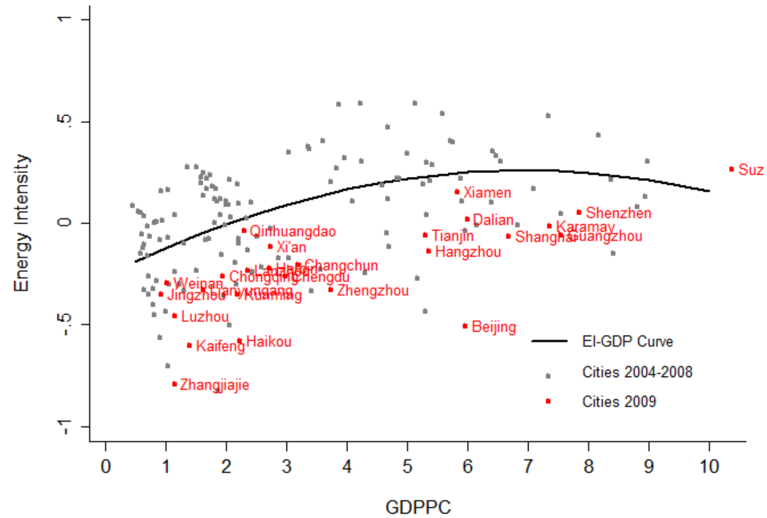


Figure 5 PM10 Gradient with Respect to GDP Per Capita (2004-2009)

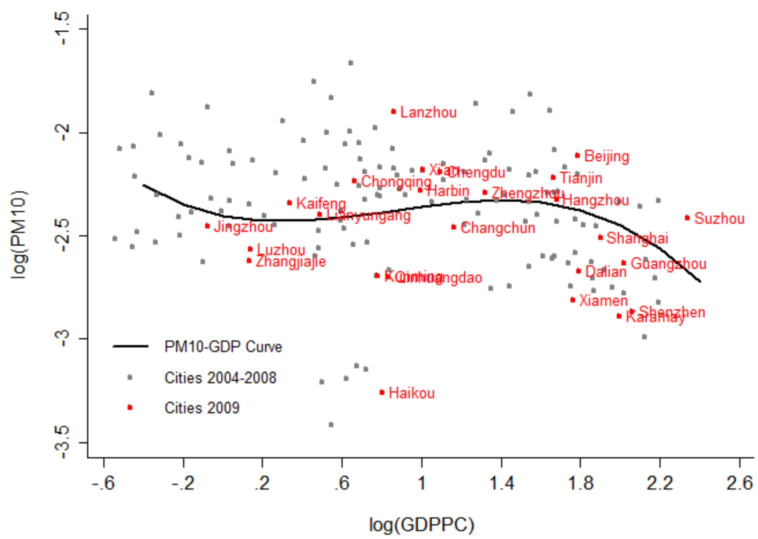


Table 1 Variable Definitions and Summary Statistics

Variable	Definition	Obs.	Mean	Std. Dev.
City attibutes				
GDPPC	GDP per capita (RMB yuan), by city by year.	498	2.58	1.67
GDP_GROWTH_M	Relative GDP growth rate comparing to the previous mayor, by city by year.	461	0.03	0.04
GDP_GROWTH_S	Relative GDP growth rate comparing to the previous secretary, by city by year.	490	0.02	0.04
POP	City population, by city by year in 1,000s.	498	535.16	397.17
EDU	Average years to schooling, by city by year.	498	6.17	4.32
DIS_HK	The distance to Hong Kong (km).	498	1292.65	687.49
INTERNET	The number of internet users in region (10 thousand), by city by year.	498	69.48	126.58
FDI	Accumulatively foreign direct investment in the city (10 thousand RMB yuan), by city by year.	498	787706.8	1363649
FACILITY_EXP	Per unit GDP annual expenditure on waste gas treatment facilities, by city by year.	498	0.408%	0.904%
RAIN	Annual Rainfall in year 1999 (mm), by province.	31	922.99	568.28
TEMP	Temperature discomfort index in year 1999, defined in Eq: $TEM_i=Sqrt\{[Winter\_temperature_i-max(Winter\_temperature)]^2+[Summer\_temperature_i-min(Summer\_temperature)]^2\}$ See Zheng, Kahn and Liu (2010)	31	19.61	6.11
Mayor attributes				
PROMOTION_M	Whether the mayor is promoted: 1=yes, 0=no, by city by year.	484	0.21	0.41
AGE_MAYOR	Mayor's age, by city by year	484	51.13	4.21
MASTER_MAYOR	Mayor's years to schooling, by city by year	484	0.40	0.49
TERM_MAYOR	Whether the mayor is on his/her second term: 1=yes, 0=no.	484	0.07	0.25
Secretary				
PROMOTION_ S	Whether the secretary is promoted: 1=yes, 0=no. By city by year.	491	0.20	0.40
AGE_SECRETARY	Secretary's age, by city by year	491	52.37	4.19
MASTER_SECRETARY	Secretary's years to schooling, by city by year	491	0.40	0.49
TERM_SECRETARY	Whether the secretary is on his/her second term: 1=yes, 0=no.	491	0.10	0.30
Environment indicators				
PCI_1	Google insight index of "environment pollution", by province by year.	186	16.76	16.28
PCI_2	Google Search Index of "Environmental Pollution", by city by year.	498	0.43	2.59
PM10	Average PM10 concentration (mg/m^3), by city by year.	498	0.09	0.03

$PM10_{p75}$	75th percentile of PM10 concentration (mg/m^3), by city by year.	498	0.12	0.03
PM10_DECLINE	Rate of decline of PM10 concentration.	461	-0.02	0.11
$PM10_{p75}$_DECLINE	Rate of decline of $PM10_{p75}$ concentration.	461	-0.02	0.12
Energy indicators				
EI	Energy Intensity: energy consumption per GDP added value (t standard coal per 10,000 RMB added value).	498	1.05	0.26
EI_DECLINE	Decline of Energy Intensity in the year.	498	0.09	0.09

Table 2　Probit Estimates of a Mayor's Promotion Probability

(Dependent Variable: *PROMOTION*, whether the mayor was promoted in that year)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP_GROWTH_M	3.710***	3.673***	3.657***	3.745***	3.738***	3.741***	3.720***
	(4.61)	(4.61)	(4.59)	(4.62)	(4.64)	(4.66)	(4.64)
PM10_DECLINE		0.319*				0.333*	
		(1.67)				(1.75)	
$PM10_{p75}$*_DECLINE*			0.358**				0.361**
			(2.10)				(2.11)
EI_DECLINE				0.312*		0.331*	0.335*
				(1.70)		(1.82)	(1.84)
FACILITY_EXP(lag1)					0.952***	1.009***	0.983***
					(2.83)	(3.01)	(2.93)
AGE_MAYOR	0.0188**	0.0180**	0.0176**	0.0185**	0.0184**	0.0170*	0.0167*
	(2.11)	(2.00)	(1.97)	(2.08)	(2.08)	(1.92)	(1.89)
MASTER_MAYOR	0.0643	0.0578	0.0519	0.0606	0.0661	0.0561	0.0499
	(0.91)	(0.82)	(0.74)	(0.86)	(0.94)	(0.81)	(0.72)
TERM_MAYOR	0.466***	0.477***	0.491***	0.456***	0.472***	0.477***	0.492***
	(2.69)	(2.76)	(2.89)	(2.60)	(2.74)	(2.74)	(2.87)
City fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	422	422	422	422	422	422	422
Pseudo R^2	0.227	0.232	0.234	0.230	0.235	0.245	0.247
chi2	87.34	88.08	90.85	87.06	92.39	93.80	96.28
Joint F test for *PM10_DECLINE* ($PM10_{p75}$*_DECLINE*),						14.88***	15.87***
EI_DECLINE and *FACILITY_EXP(lag1)*						(0.0019)	(0.0012)

Notes: (1) z-statistics are reported in parentheses. (2) ***: significant at the 1% level; **: significant at the 5% level;*: significant at the 10% level. (3) See Table 1 for variable definitions.

Table 3 Public Concern Index Regressions

Dependent Variables	**log(*PCI_1*)**	**log (*PCI_2*)**
	(1)	(2)
log(*D_HK*)	-1.417***	-0.500***
	(-3.46)	(-5.05)
log(*INTERNET*)	1.118*	0.241*
	(1.90)	(1.84)
log(*PM10*)	1.632*	0.524**
	(1.74)	(2.07)
log(*GDPPC*)	3.254***	0.0516
	(4.91)	(0.35)
log(*POP*)	-2.804***	0.538***
	(-4.47)	(4.85)
EDU	0.961	0.265***
	(1.33)	(3.13)
Constant	3.292	6.056***
	(0.40)	(2.80)
East/west/central region dummies	Yes	Yes
Year fixed effects	Yes	Yes
Standard errors clustered	By province	By city
Observations	180	498
R^2	0.505	0.492

Notes: (1) t-statistics are reported in parentheses. (2) ***: significant at the 1% level; **: significant at the 5% level;*: significant at the 10% level. (3) See Table 1 for variable definitions.

Table 4 Environmental Outcomes as a Function of Mayor Attributes and Public Concern

Dependent Variables	log(*FACILITY_EXP*)		log(*EI*)	
	(1)	(2)	(3)	(4)
log(*PCL_1*) (*lag1*)	0.0793*		-0.00279	
	(1.88)		(-1.38)	
log(*PCL_2*) (*lag1*)		0.0950***		-0.000758
		(3.15)		(-0.13)
log(*GDPPC*)	0.716***	1.372***	-0.291	-0.669***
	(3.08)	(7.68)	(-1.35)	(-19.27)
log(*POP*)	0.191	2.210**	-0.773	-1.410***
	(1.23)	(2.20)	(-1.41)	(-5.63)
Constant	-4.229***	-18.00**	4.786	11.52***
	(-2.99)	(-2.22)	(1.32)	(5.73)
Province fixed effects	Yes	-	Yes	-
City fixed effects	-	Yes	-	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	153	415	153	415
R^2	0.939	0.901	0.951	0.946

Notes: (1) t-statistics are reported in parentheses. (2) ***: significant at the 1% level; **: significant at the 5% level;*: significant at the 10% level. (3) See Table 1 for variable definitions.

Table 5 City Leaders' Attributes and Environmental Outcomes

	$\triangle PM10$	$\triangle PM10_{p75}$	$\triangle EI$	$\triangle FACILITY\_EXP$
	(1)	(2)	(3)	(4)
⊿EDU_MAYOR	-0.00212**	-0.00237**	-0.00870	-0.297
	(-2.59)	(-2.17)	(-1.30)	(-0.90)
⊿POP	0.0101*	0.0131*	0.0700**	-2.53**
	(1.80)	(1.77)	(2.06)	(-2.55)
⊿YEAR	0.00248**	0.00427**	-0.0471***	3.09***
	(2.03)	(2.43)	(-4.28)	(3.28)
PM10_lag	-0.186***			
	(-3.07)			
$PM10_{p75}\_lag$		-0.231***		
		(-3.30)		
EI_lag			-0.117***	
			(-2.99)	
FACILITY_EXP_lag				0.646
				(1.64)
Observations	70	70	88	88
R^2	0.296	0.299	0.760	0.440

Notes: (1) t-statistics are reported in parentheses. (2) ***: significant at the 1% level; **: significant at the 5% level;*: significant at the 10% level. (3) See Table 1 for variable definitions.

Table 6 Energy Intensity and PM10 Gradients with Respect to GDP Per Capita

	Trend Regressions		*Baseline EKC Regressions*	
	log(*PM10*)	log(*EI*)	log(*PM10*)	log(*EI*)
	(1)	(2)	(3)	(4)
log(*POP*)	0.135***	-0.00106	0.00126	0.163***
	(6.89)	(-0.07)	(0.04)	(4.60)
			GDPPC	log(*GDPPC*)
			0.152***	-0.189**
			(4.29)	(-2.16)
			$GDPPC^2$	$\log(GDPPC)^2$
			-0.0110**	0.383***
			(-2.44)	(3.06)
				$\log(GDPPC)^3$
				-0.150***
				(-2.91)
log(*RAIN*)			-0.0381	-0.126*
			(-0.71)	(-1.84)
log(*TEMP*)			-0.149	0.275
			(-1.42)	(1.61)
year=2005	-0.0675	0.000800	Year dummies:	Year dummies:
	(-1.32)	(0.03)	Yes	Yes
year=2006	-0.0512	-0.0933***		
	(-1.00)	(-2.93)	Peak turning point	Peak turning point
year=2007	-0.105**	-0.219***	(2003 RMB 10,000)	(2003 RMB 10,000)
	(-2.16)	(-7.17)	6.91	4.07
year=2008	-0.142***	-0.346***		
	(-2.96)	(-11.21)	(2003 US dollars)	(2003 US dollars)
year=2009	-0.165***	-0.371***	8324	4904
	(-3.44)	(-11.95)		
Constant	-3.132***	0.199**		
	(-24.18)	(2.19)		
Observations	498	498	498	498
R^2	0.112	0.354	0.558	0.372

Notes: (1) t-statistics are reported in parentheses. (2) ***: significant at the 1% level; **: significant at the 5% level;*: significant at the 10% level. (3) See Table 1 for variable definitions.

Table 7 Peak Turning Points on EI-GDP and PM10-GDP Curves (by City Type)

		(1)	(2)	(3)	(4)	(5)	(6)
		PCI_1		*PCI_2*		*PCI_1&PCI_2*	
		Higher	*Lower*	*Higher*	*Lower*	*Higher*	*Lower*
EI	(RMB 10,000)	5.24	7.61	6.62	8.23	4.41	7.55
	(US dollar)	6319	9166	7979	9912	5314	9092
PM10	(RMB 10,000)	3.48	4.27	3.66	4.48	2.53	4.20
	(US dollar)	4193	5145	4412	5400	3052	5058
		(7)	(8)	(9)	(10)	(11)	(12)
		City human capital		*Mayor education*		*CCP secretary education*	
		Higher	*Lower*	*Lower*	*Higher*	*Lower*	*Lower*
EI	(RMB 10,000)	6.45	8.17	7.41	8.29	6.78	6.99
	(US dollar)	7773	9838	8922	9990	8172	8423
PM10	(RMB 10,000)	3.93	6.27	4.06	4.30	3.75	4.10
	(US dollar)	4735	7554	4892	5181	4518	4940

Notes: (1) Variables are the same with equation (3) and (4) in Table 6. (2) See Table 1 for variable definitions. (3) "*Human Capital*" is measured as the ratio of people who have the highest educational attainment as senior high school or above.

Appendix

Table A1 CCP Secretaries' Promotion Equation with Environmental Variables

(Dependent Variable: *PROMOTION*, whether the secretary gets promoted in that year)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP_GROWTH_S	4.434***	4.418***	4.417***	4.443***	4.500***	4.495***	4.494***
	(5.59)	(5.58)	(5.56)	(5.58)	(5.63)	(5.62)	(5.60)
PM10_DECLINE		0.190				0.201	
		(1.06)				(1.12)	
$PM10_{p75}$*_DECLINE*			0.201				0.211
			(1.19)				(1.25)
EI_DECLINE				0.0778		0.0805	0.0814
				(0.43)		(0.46)	(0.46)
FACILITY_EXP(lag1)					0.786	0.825	0.825
					(1.39)	(1.47)	(1.47)
AGE_SECRETARY	0.00505	0.00448	0.00429	0.00483	0.00447	0.00358	0.00339
	(0.74)	(0.66)	(0.63)	(0.71)	(0.66)	(0.54)	(0.51)
*MASTER_*	-0.200***	-0.203***	-0.203***	-0.198***	-0.196***	-0.197***	-0.198***
SECRETARY	(-4.33)	(-4.44)	(-4.45)	(-4.27)	(-4.25)	(-4.30)	(-4.30)
TERM_ SECRETARY	0.471***	0.476***	0.477***	0.470***	0.492***	0.498***	0.500***
	(3.09)	(3.11)	(3.11)	(3.09)	(3.26)	(3.29)	(3.29)
City fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	443	443	443	443	443	443	443
Pseudo R^2	0.264	0.266	0.267	0.265	0.268	0.271	0.272
chi2	102.7	100.3	101.2	102.4	101.5	98.73	99.73
Joint F test for *PM10_DECLINE* ($PM10_{p75}$*_DECLINE*),						3.14	3.77
EI_DECLINE and *FACILITY_EXP(lag1)*						(0.333)	(0.288)

Notes: (1) z-statistics are reported in parentheses. (2) ***: significant at the 1% level; **: significant at the 5% level;*: significant at the 10% level. (3) See Table 1 for variable definitions.

Table A2 CCP Secretaries' Attributes and Environmental Outcomes

	△*PM10*	**△*PM10*$_{p75}$**	**△*EI***	**△*FACILITY_EXP***
	(1)	(2)	(3)	(4)
⊿EDU_ SECRETARY	-0.00104	-0.00136	0.00715	-1.16
	(-1.36)	(-1.46)	(0.97)	(-0.88)
⊿POP	0.00648	0.0109	0.134	-0.663
	(1.03)	(1.56)	(1.20)	(-0.18)
⊿YEAR	-0.000250	-0.000248	-0.0538***	1.60*
	(-0.25)	(-0.20)	(-5.99)	(1.85)
PM10_lag	-0.0621			
	(-1.46)			
PM10$_{p75}$*_lag*		-0.0626		
		(-1.59)		
EI_lag			-0.103***	
			(-3.28)	
FACILITY_EXP_lag				0.425*
				(1.79)
Observations	74	74	91	91
R^2	0.193	0.198	0.768	0.163

Notes: (1) t-statistics are reported in parentheses. (2) ***: significant at the 1% level; **: significant at the 5% level;*: significant at the 10% level. (3) See Table 1 for variable definitions.