Pollution for Promotion*

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Abstract

This paper provides evidence on the impact of political incentives on the environment using the case of China's pollution during 1993–2010. Exploring variation in governors' connections with key officials in the center, I document that gaining connections increases pollution (measured by satellite and official data). I also find that connected governors increase coal-fired power production more when less precipitation makes it more difficult to rely on hydropower. These results highlight the importance that career incentives play in influencing environmental outcomes, and they propose a potential pathway for mitigating environmental challenges through the recalibration of political incentives.

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1 Introduction

How do political incentives affect the environment? In democracies, politicians often face a trade-off between creating jobs to gain votes and protecting the environment. The Ilva steelworks pollution scandal in southern Italy in 2012 is an example of deliberate political neglect because Ilva was an important job provider. Even without electoral incentives, politicians can also be attracted by rents offered by private firms in exchange for tacit permission to conduct environmentally harmful economic activities. Global Witness (2012) reports that officials and private companies in Liberia have colluded to secure logging permits and cut down pristine forests. Motivated by many real-world cases, research on the political economy of the environment has been growing. This paper offers evidence from China and demonstrates that its environmental challenges can partly be explained by politicians' incentives.

China during 1990–2010s, in many ways, provides an ideal context for such a study. Its phenomenal growth rates over the last three decades have been fueled by fossil energy sources with adverse impacts on the environment, both within China and across the globe.[1] Air pollution, as measured by the ambient concentrations of particulate matter (PM) and sulfur dioxide (SO_2), was once among the worst in the world. Across China, only 1% of urban dwellers breathed air that would be considered safe by the European Union (*The New York Times* 2007). The pollution problem is by no means limited to the air, however, and water pollution is another pressing challenge.[2] Part of the explanation for the pollution problem is structural change. In this respect, the pollution problem in China shares common features with industrialized societies when they were less developed. But relative to its developmental stage, China has relied on an unusually large amount of polluting industries (Vennemo et al. 2009). The reason is generally suspected to be political: abundant anecdotal evidence

[1] For example, China overtook the United States in 2006 as the world's biggest emitter of carbon dioxide. Another example is that sulfur dioxide and nitrogen oxide spewed by China's coal-fired power plants fall as acid rain on Seoul, South Korea (*The New York Times* 2007).

[2] See *The River Runs Black* (Economy 2004) for a vivid description of water pollution in China.

suggests that many polluting technologies are *conscious* choices by political leaders.[3]

The logic behind the anecdotal evidence is that politicians welcome polluting technologies in their regions when they have strong incentives to enhance growth, because economic growth is relevant for their chance of promotion. In this paper, I formalize this logic in a simple career-concerns model with choices of clean and dirty technologies as well as effort. In particular, I use political connections between local governors and key officials at the political center as a source of variation in the career concerns emphasized in the model.[4] I focus on political connections for two reasons. First, political connections are considered to be an important factor in motivating politicians in China.[5] Second, due to frequent reshuffling of officials, there exist arguably exogenous variations in political connections. Empirically, I show that connections and economic growth appear to be complements for promotion in the data. In other words, connections increase the marginal value of economic performance and hence provide a reasonable candidate for variation in career concerns. Following this logic, connections increase the marginal values of dirty technologies and effort. As a result, the framework predicts that connections increase pollution for a given level of effort. Meanwhile, more effort allows the politician a larger budget to afford more dirty inputs. If the production technology is decreasing returns to scale in the two types of technologies, the framework predicts that the impact of connections on pollution is more than proportional to their impact on production. The simple framework also predicts that a higher relative price of clean technologies increases the use of dirty technologies due to a substitution effect and that this effect is further strengthened by political connections.

Empirically, I collect a panel dataset across 30 Chinese provinces between 1993 and

[3] For example, a report by Xu et al. (2011) suggests that the aim for higher GDP constitutes the root of Yangtze River pollution. Another report by Qie (2012) argues that many polluting projects are constructed without the permission of environmental bureaus due to local government support.

[4] I look at both governors and party secretaries in the empirical analysis and find that the impact of governors is more important. One explanation is that governors were in charge of economic activities. I present the results on party secretaries in the appendix as a comparison.

[5] Almost all the literature on promotion in China has noted the importance of connections, pioneered by Li and Zhou (2005) and Shih et al. (2012). My contribution is to refine the definition of connections and test the relevance of political incentives in explaining environmental outcomes.

2010 to examine the link between political connections and pollution.[6] There are two main empirical challenges. The first is identification, since connections (defined as a dummy indicating whether a governor has past colleagues in the Politburo Standing Committee in a given year) are not necessarily exogenous. For instance, connected politicians might be appointed to "better" regions where they can develop the economy without relying on dirty industries or "worse" regions as a test of their ability. I use three strategies to deal with this concern. First, using within-province variation in connections, I conduct a standard difference-in-differences analysis and show that there are no differences in pre-trends. Second, in principle, exploiting within-governor variation in connections addresses the concern of endogenous appointment, as some governors are already ruling certain provinces and their connections change due to reshuffling in the center.[7] I should note that, in my context, such variation comes from a small sample – only 10% of the observations have such variation. Thus, this strategy can be considered as a case study to provide further support. Third, I focus on the case of electricity generation where coal-fired power and hydropower are the main sources. When less precipitation makes it more difficult to produce hydropower, the model predicts that connected governors increase coal-fired power production more. Since precipitation is likely to be exogenous, examining how connected governors respond to such exogenous shocks also partially addresses the endogeneity concern.

Another empirical challenge, general for studies on the political economics of contemporary China, is data quality. This concern is particularly important in this context since pollution is subject to gaming by politicians. To address this challenge, I focus on satellite information on Aerosol Optical Thickness (AOT), a measure highly correlated with pollution.[8] I also use official data on two major pollutants, namely Chemical Oxygen Demand

[6] I start from 1993 because this is the year to which the detailed biographical data of politicians and pollutants can be traced back. Meanwhile, it is the division year of fiscal decentralization, which provides a stronger incentive for local politicians to generate growth. Tibet is excluded from the analysis because its information is often missing.

[7] The within-governor strategy is similar to that in Blanes i Vadal et al. (2012), who exploit within-lobbyist variation to evaluate the impact of connections on revenues of lobbying firms. Xu (2018) uses a within-governor strategy to study political selection in colonial India.

[8] Chen et al. (2012) evaluate the quality of the official pollution index data at the city level. Linking city-

(COD) in industrial waste water (measured data), and industrial Sulfur Dioxide (SO_2), a major pollutant in the air (reported data). The results are generally not precisely estimated when I use official data. Nevertheless, the magnitude of the impact using official data is comparable to that using satellite data: the impacts of gaining connections on AOT and the two official pollutants are both around 10%–13% of the standard deviation of different pollution measures. In the case of electricity production, coal-fired power increases by 3.5% when precipitation is less abundant (below the 75th percentile), with a higher impact (about 13%) for connected governors.

These results are consistent with the interpretation that connections strengthen the career concerns of politicians and increase the marginal payoff of pollution. However, connections might also affect pollution through other channels. In particular, connected governors may get more resources from the center directly. Additionally, connected officials might be protected in the sense that their career is less likely to be affected even if they pollute more. I do not find strong evidence for these two interpretations and discuss why they may work together with career concerns.

This study is an application of the theory of incentives in firms to the organization of governments. Since the seminal paper by Holmström (Holmström 1982, 1999), the theory of career concerns has been widely applied to the behavior of government agencies in both theoretical models (Dewatripont et al. 1999; Alesina and Tabellini 2007) and empirical analysis (e.g., Besley and Case 1995; Xu 2018). In the Chinese context, influential research has linked political incentives with economic growth performance (e.g., Li and Zhou 2005; Xu 2011). Built on this literature, this paper provides new evidence on an important consequence of career concerns and suggests it is important to consider the political incentives when designing policies to fight pollution in China.[9] My findings also add to a literature on the political economy of the environment (e.g., List and Sturm (2006) on how election incentives

level index with satellite information, they find that the official data have useful information on pollution, despite some bunching related to blue sky standards.

[9] This is not to say that career concerns are the only dimension of political incentives. Persson and Zhuravskaya (2016) is an example emphasizing the limit of career concerns.

affect environmental policies in the US and Burgess et al. (2012) on how private incentives of local politicians increase the deforestation in Indonesia).[10]

Moreover, this study offers a new perspective to an extensive literature on political connections. Most of the existing studies emphasize the favoritism channel of connections (see Fisman 2001, Shih 2004, Khwaja and Mian 2005, Opper and Brehm 2007, Shih et al. 2012 among many others). My findings suggest that connections can also affect the effort and policy choices of politicians. While this channel may work together with favoritism, it has a very different implication. In this context, the incentive channel implies that connected politicians may work even harder; in contrast, connected politicians would just rely on help from the center if favoritism were the only channel. The difference between the two channels is likely to be relevant in other contexts yet has been less well studied than favoritism per se.

It should be highlighted that in recent years, the Chinese government has made significant progress in addressing the challenges posed by pollution (Greenstone et al. 2021). A pivotal shift underpinning this progress is the recalibration of the relationship between economic growth and political promotion. In alignment with the political rationale delineated in this paper, the reconfiguration of promotion incentives paves the way for effectively tackling environmental challenges.

2 Conceptual Framework

To guide my empirical analysis, I present a simple framework. The main purpose is to not to model the pollution generation process but to highlight the role of political incentives. I summarize the key elements and insights from the framework here and present the details

[10]Related studies have examined the correlations between environmental protection and promotion and have not reached any conclusion. For instance, Wu et al. (2012) show that the investment in environmental protection does not increase the chance of promotion for city leaders, which provides an indirect way of understanding why leaders have no incentive to invest in environmental protection. My focus is to explain pollution as an outcome of political incentives rather than examine how pollution itself contributes to promotion.

of the model in Appendix A.

The framework has three main features. First, there is a positive link between career concerns and output. This feature is shared by the standard career-concerns model (Holmström 1982). Second, there are at least two inputs, one clean and one dirty, with the clean one being more expensive. This feature is shared by the literature on trade and the environment that treats emissions as an input (Copeland and Taylor 2004). Finally, variation in career concerns is allowed. I model this feature as connections to the key officials in the Center. Specifically, I assume that connections and growth are complements for promotion, which is the main finding in Jia et al. (2015) and is briefly discussed in Section 3.1.

With these three features, a Local Governor (G_L) is motivated by career concerns to satisfy the Central Government (G_C). Different from the standard career-concerns model, G_L responds to career concerns by making two choices: one is on the level of effort positively associated with his budget and the other is how to allocate his budget between a clean input and a dirty input.

Local Governors differ in their political connections. Due to the complementarity between connections and growth in political promotion, the marginal return of growth is higher for connected governors. Consequently, connected governors choose more effort, which allows for more dirty inputs. If the production function is decreasing returns to scale in the two types of input, we expect to observe more pollution for connected governors, conditional on output (real GDP).

Moreover, there exists a substitution effect between technologies: a higher price of the clean input naturally leads to an increase in dirty input. This substitution effect is further strengthened by political connections, following the same logic above. I use the case of electricity production as a laboratory to evaluate how the choices between coal-fired power and hydropower vary with precipitation shocks.

3 Background and Data

Section 3.1 presents the data on connections and discusses the main assumption in the conceptual framework. Section 3.2 presents the two sources of pollution data: monthly satellite data available since 2000 and yearly official data available since 1993. Section 3.3 discusses the case of electricity generation. To focus on the politicians who are most likely to affect economic outcomes, I exclude those who hold office for less than two years, leaving a sample of 114 governors ruling 30 provinces during 1993–2010.

3.1 Connection and Promotion

Definition of Connections Corresponding to C in the model, I look at the provincial governors' connections to the Politburo Standing Committee members. I focus on provincial governors because they are the officials in charge of economic activities.[11] The promotion of provincial governors is controlled by the Politburo, a group of about twenty people who oversee the Communist Party of China. Unlike politburos of other Communist parties, power within the Politburo is centralized in the Politburo Standing Committee (PSC).[12] Hence, I mainly exploit the connections with the PSC members.[13] Memberships in the PSC as well as the Politburo at large are renewed every five years. In the period of interest, the number of PSC members increases from seven to nine.

Anecdotal evidence suggests that connections have a significant effect on promotion, as the members in the PSC tend to promote people connected with themselves. The "Shanghai Clique" and the "League Faction" are two popular phrases coined for this phenomenon. The

[11] I do not find that the connections of party secretaries have positive impacts on pollution. This may be because their major responsibilities include the implementation of the central government policies and social stability whereas governors' key duty is to promote growth. See Tan (2006) for qualitative discussions on the roles of party secretaries and governors. For example, when the Central government decided to crack down on Falun Gong organizations, "while provincial governors were more concerned about the possible fallout on the economy, Party Secretaries were more preoccupied with taking the correct political line and implementing the central decision" (Tan 2006).

[12] See Lawrance and Martin (2012) for the organization of the Politburo as well as a general picture of China's political system.

[13] Connections with non-standing members do not have significant impact on promotion, as shown in Jia et al. (2015).

“Shanghai Clique” refers to the politicians who previously worked with the former CPC General secretary, President Jiang Zemin, in his Shanghai administration. Many of these people were promoted when Jiang became President and head of the PSC. The “League Faction” refers to the group of politicians who share work experience with the former CPC General secretary, President Hu Jintao, who held various Youth League positions in his political career.

To formally capture such anecdotal evidence, I use a network dataset based on the biographical data of provincial leaders and Politburo members between 1993 and 2010. It contains biographical data on Chinese leaders, including detailed information about their education history and job history. Connections can be defined in different ways: having been work colleagues, having studied at the same university, or sharing the province of origin. With respect to each type of connection, the connection variable C_{ijt} can be defined in two ways: (1) a connection dummy for whether governor j of province i has at least one connection with a PSC member in year t, i.e., $\mathrm{C}_{ijt} = \mathcal{I}(\mathrm{C}_{ij} * \mathrm{PSC}_{jt} > 0)$, where C_{ij} indicates that i and j used to be colleagues and PSC_{jt} indicates that j is a member of PSC in year t; and (2) the number of connections between governor j of province i PSC members at year t, i.e., $\#\mathrm{C}_{ijt} = \sum_j \mathcal{I}(\mathrm{C}_{ij} * \mathrm{PSC}_{jt} > 0)$. Since the maximum number of connections for a governor in a year is two, the two variables do not differ dramatically. I use the dummy for connections in the baseline estimations and employ the number of connections as a robustness check. Jia et al. (2015) find that having been work colleagues matters most for promotion, which is my focus of connections henceforth.

Figure 1 gives an example of how the connections are defined. Based on the CVs of two politicians, I know that they worked together in the 1980s and 1990s ($\mathrm{C}_{ij} = 1$). B was a governor in J Province between 2001 and 2006 while A became a PSC member in November, 2002. Therefore, B was not connected to the PSC between 2001 and 2002 but got connected since 2003.

Figure 2 maps the spatial distribution of the connections, by the mean of having connected governors in all the years given a province. One cannot see any systematic pattern of allocation from the map. For example, Guangdong and Beijing in the east enjoy similar likelihood of having connected governors as Xinjiang and Qinghai in the west. This pattern does not deny endogenous appointment but suggests that the bias due to endogenous appointment may not necessarily work toward one direction. The map also suggests that there are more connected governors in a few provinces in the North Plain (Shanxi, Shandong, Henan, and Tianjin). To make sure that my findings are not driven by these specific provinces, I will conduct a robust check by excluding these provinces.

This definition of connections provides a detailed characterization of connections among Chinese top politicians. In particular, the connection dummy is not only time-variant within provinces but also time-variant within a group of politicians. This variation provides further information beyond the definitions of connection in related studies (Shih 2004; Opper and Brehm 2007; Shih et al. 2012) where connections are taken as a fixed personal characteristics. As presented in panel (a) of Table 1, 19% of the provincial-year observations are connected.

Correlation with Provincial and Individual Characteristics I collect a set of provincial and individual characteristics to check their correlations with the connection measure. As an important concern is that connection is affected by the growth trend, I calculate the average real GDP growth in the preceding year, as well as that in the three and five preceding years before getting connected. I also include log real GDP and log population at the province level to allow for possible correlations between production and pollution.

At the individual level, I collect information on the governor's age, whether he has a college degree, whether he has served in the central government, whether he is ruling his birth province, and whether he is in his second term. The summary statistics of these variables are presented in panel (b) of Table 1.

Table 2 presents the correlations between these characteristics and the connection dummy. Columns (1)-(3) present the cross-province correlations and columns (4)-(6) present the within-province correlations by including province fixed effects. Across provinces, connections are positively correlated with log GDP and negatively correlated with log population, indicating that more developed provinces are more likely to be connected. These correlations are not significant any more once I include province fixed effects.

At the individual level, connections are positively correlated with being older, having served in the center, and negatively correlated with ruling one's birth province. These correlations are not surprising. For instance, having served in the center increases the likelihood of working together with the (future) PSC members. I will control for these provincial and individual characteristics in my analysis. Among the pre-connection growth variables, I focus on the average growth in the three preceding years before getting connected. Thus, the control variables in my analysis below are those listed in column (2) of Table 2.

Examining the Assumption in the Conceptual Framework An important assumption in the conceptual framework is that connections and performance are complementary for promotion. Here, I discuss statistical support for the assumption. Since this pattern has been documented in Jia et al. (2015), it is not the main contribution of this paper and is presented in Appendix Table B.1.

The research on the promotion of Chinese politicians has been controversial because the definitions of promotion vary across studies (Tao et al. 2010). Here, I present the results where promotion of governors refers to becoming a party secretary or a minister and promotion for secretaries refers to becoming a Politburo member.[14] In line with the underlying literature, GDP growth is measured the average annual real GDP growth since assuming office.

Column (1) of Appendix Table B.1 shows that connections are positively correlated with promotion. While the estimate is not very precise, the effect is large: the connection dummy increases the promotion probability by around six percentage points whereas the

[14] See Jia et al. (2015) for more robustness checks using broader definitions by including the positions of vice-chairmanship of the National People's Congress and vice-chairmen of the National Committee of the People's Political Consultative Conference as promotion.

mean promotion rate is around ten percentage points. This finding is consistent with the argument on connections in the political-science literature such as Shih et al. (2012). Column (2) presents the results for both GDP growth and connection. Both coefficients are not precise but sizable. My focus is the interaction effect of growth and connection presented in columns (3)-(5). Column (3) only includes province fixed effects and year fixed effects, column (4) adds a vector of provincial and individual characteristics discussed above (i.e., those listed in column (2) of Table 2) and column (5) allows the impacts of these characteristics to vary by economic growth. As shown, the interaction of growth and connections has a strong impact on promotion: conditional on gaining connection, a one standard deviation increase in economic growth (0.025) increases the promotion probability by eight percentage points, around 80% of the mean.

In addition, column (6) presents a horse-race test between connecting with current PSC members and connections with past/future PSC members. As shown, the interaction effect is driven by connections with current PSC members. This result suggests that the finding is specific to connections with those being in power rather than some general elite tracks. It also provides a placebo measure of connections which I will use in my analysis on pollution.

3.2 Measuring Pollution

Satellite data: AOT To address the concern of data quality, I use Aerosol Optical Thickness (AOT) provided by NASA to measure pollution. AOT measures the degree to which aerosols prevent the transmission of light by absorption or scattering of light, which is highly correlated with air quality. For example, using data in Alabama in 2002, Wang and Christopher (2003) show that the correlation coefficient between the monthly means of AOT and PM 2.5 is around 0.7 whereas the correlation coefficient between the monthly means of AOT and Air Quality Index is above 0.9.

Monthly information on AOT is available at 0.5 degree by 0.5 degree since 2000. In my analysis, I use the mean of AOT in given month in a province. The mean of AOT in the data is 0.21 and the standard deviation is 0.14.[15] To facilitate interpreting the magnitude, I normalize the AOT measure by its standard deviation.

Official Data: COD and SO_2 I collect data on two major pollutants in each province i and year t: Chemical Oxygen Demand (COD) in industrial waste water and industrial Sulfur Dioxide (SO_2). The source of these data is *China Environment Yearbooks,* available between 1993 and 2010.[16] The COD and SO_2 data presented in the yearbooks is the amount (in tons) discharged into surface water or air. As explained in the yearbooks, the numbers are obtained in two distinct ways. COD is measured at certain monitoring points and its quantity is obtained by multiplying the average COD density at the monitoring point and the volume of waste water. On the other hand, SO_2 is imputed by multiplying reported uses of energy and SO_2 emission coefficients for different types of energy. Because the COD data really measures the quantity of pollutants, it may contain more precise information about pollution than SO_2. The amount of COD and SO_2 are measured in 10^4 tons.

To reduce the influence of large values, I focus on the logs of COD and SO_2. The mean and standard deviation of log COD are 11.75 and 1.11 whereas those for log SO_2 are 3.69 and 0.99 (summarized in panel (c) of Table 1.) In addition, I calculate the average z-score of these two measures (which is also standardized) and compare the impact of connections on the average z-score with that using satellite data.

3.3 The Case of Electricity Generation

The electricity-generation sector provides a useful testing ground for the choice between dirty and clean technologies for two reasons. First, electricity production in China reflects

[15] As a comparison, the mean of AOT for the United States is around 0.15 during this period. According to geophysical research such as Dey and Di Girolamo (2011), a change of AOT at the magnitude of 0.01 already indicates a significant change.

[16] The year information refers to the data rather than the yearbook. The information in year t is reported in yearbook $t + 1$. This is true for all yearbooks used in this paper.

provincial policies, as the electricity market in China is far from being integrated. Because electricity is critical for production, it often becomes a constraint for the growth of provinces since many industries are in dire need of power, while inter-provincial electricity trade is limited by regional protectionism (see Yang (2006) for a detailed description of the evolution and Lin and Purra (2012) for the challenges of the electricity sector).

Second, there are mainly two technologies for producing electricity in China: one is dirty (coal-fired thermal power) and the other is clean (hydropower).[17] In 2010, coal-fired power accounted for 80.3% of the total electricity power whereas the hydropower accounted for about 18.4%. Nuclear, wind and other sources together only have a share of 1.3%. Coal-fired power is a major source of pollution, which accounts for more than 50% of industrial SO_2 emissions. In recent years, the central government has attempted to limit the use of coal-fired power through policies such as the Two-Control Zones policy.[18] It is often reported that the incentive for promoting growth makes the aim of limiting the use of coal-fired power impossible to realize, especially when precipitation is not abundant (*Life News* 2010). Less precipitation naturally makes the relative price of hydropower higher and hence coal-fired power more attractive.

Coal-fired Power Provincial-level coal-fired power production is measured in 10^4 kilowatt hours. The data source is *China Electricity Yearbooks*. As shown in panel (d) of Table 1, the mean and standard deviation of log coal-fired power are 5.81 and 1.01.

Precipitation Provincial-level precipitation data are aggregated from monthly grid-level information with ArcGIS, provided by the Climate Prediction Center Merged Analysis of Precipitation (CMAP) at NOAA, available between 1993 and 2010. I first sum the twelve

[17]Being clean means not generating air pollution in this context. Of course, hydropower can also have adverse consequences on the environment such as deforestation.

[18]The "Two Control Zone" policy refers to the policy entitled "Acid Rain and Sulfur Dioxide Emission Zones". It was launched by the Central government in 1996, in order to control SO_2 emissions. Since this policy applies to 175 cities/districts in 27 provinces, it is unlikely to contaminate my results. But it is worthwhile studying the impact of this policy with city-level or county-level data.

months of rainfall to get the yearly data for each grid. Then, I use the median of the grid-level data as my measure of provincial-level precipitation. The result is similar if I use the mean of the grid-level data.

To ensure there are enough observations of being connected and with less precipitation, I define "less precipitation" as a dummy indicating that the precipitation level is below the 75th percentile. Following this definition, 13% of the province-year observations belong to the group of both being connected and with less precipitation (reported in panel (d) of Table 1). The results presented are robust to varying this definition slightly. However, it is not reasonable to define this dummy very narrowly, as there would be too few observations of both being connected and with less precipitation.

4 Empirical Strategy and Results

Section 4.1 presents the main empirical strategy. Section 4.2 reports the main empirical findings using satellite data and Section 4.3 discusses several robustness checks. Finally, Section 4.4 examines the production of coal-fired power when the precipitation is less abundant.

4.1 Empirical Strategy

The main estimation strategy is similar to a difference-in-differences (DD) strategy, where I compare the pollution outcomes before and after a province gets connected. The baseline specification is as follows:

$$E_{igt} = \beta_C C_{igt} + X'_{igt}\gamma + \alpha_i + \lambda_t + \varepsilon_{igt}, \tag{1}$$

where E_{igt} is pollution outcomes under the administration of governor g in province i and year t (or in a given month when using monthly satellite data).

α_i indicates province fixed effects. λ_t indicates year fixed effects (and also month fixed effects when using monthly satellite data); C_{igt} the connection dummy indicating whether governor g in province i is connected to a PSC member in year t; X_{igt} is a vector of controls presented in Table 2.

The baseline estimates always control for province and year fixed effects. These fixed effects control for all time-invariant differences between provinces and time-variant changes that affect all provinces similarly. I also control for governor fixed effects in some specifications to check the importance of endogenous appointment.

In addition, I control for regional-specific (nonparametric) trends in some specifications by including region × year fixed effects, where regions refer to the East, the West and the Central. One reason for doing this is that macro policies are usually implemented according to this categorization such as the program to "Open Up the West" and the plan of "the Rise of Central China". Controlling for region × year fixed effects is a flexible way of taking into account the impact of macro policies during the time horizon of this study. All standard errors are clustered at the province level.

4.2 Main Results Using Satellite Data

The baseline results for monthly AOT (normalized by its standard deviation) are presented in Table 3. Column (1) presents the results after controlling for province, year and month fixed effects, and shows that connections increase AOT by about 12.6% of its standard deviation. Column (2) includes all the controls listed in Table 2, while column (3) further includes region-specific trends (East*Year dummies and West*Year dummies). These within-province estimates are stable across specifications, implying that gaining connections increase AOT by 11%-13% of its standard deviation.

Columns (3)-(6) of Table 3 present the results after including governor fixed effects. In these specifications, the variation in connections is driven by the reshuffling at the center. This strategy partially addresses the endogenous appointment concern: these governors are already appointed to certain provinces and the change of their connections is due to the reshuffling in the center, which is likely to be exogenous to their own characteristics. As mentioned in the introduction, the variation comes from a small group of observations, the strategy can thus be considered as a case study. Nevertheless, the results within this group are comparable to the results using within-province variation and provide further support for the connection-pollution link.

Equation (1) captures the average effect of gaining connections over time. A more flexible way of examining the effects is to study how the pollutants evolve in the years before and after the change in C_{igt}. Hence, I look at the dynamic effects of gaining connections by estimating the following regression:

$$E_{igt}=\sum_{\tau=-2}^{\tau=3+}\beta_{\tau}\mathrm{C}_{ig\tau}+\mathrm{X}'_{igt}\gamma+\alpha_i+\lambda_t+\varepsilon_{igt}, \tag{2}$$

where three or more than three years before getting connected are left as the reference group. $\tau = -j$ (or j) indicates j years before (or after) getting connected.

Columns (1)-(3) of Table 4 present the results using similar specifications as columns (1)-(3) of Table 3.[19] As shown, β_{-2} and β_{-1} are not significant, indicating no systematic pre-trends. In contrast, a significant impact of connections is seen after getting connected. These results further suggest that the association between connections and pollution is specific to the role of gaining connections rather than omitted provincial characteristics that induce connections. Moreover, the impacts appear stronger in the first two years after getting connected, which is consistent with the short horizon of governors – the average length in office for a governor is around four years.

4.3 Robustness Checks

Using Official Data While official data suffer from the quality concern, it is still useful to check whether they exhibit a similar pattern. Columns (1)-(4) of Table 5 present the results for log COD. The within-province estimates are less precise than the within-governor

[19] In some cases, a province first switched from being not connected to being connected, and then switched to being not connected. I exclude the last group of observations in the dynamic analysis.

estimates. But their magnitudes are similar (around 11%). Given that the standard deviation of log COD is 1.11, the magnitude of the effect is also comparable to that using satellite data.

Similarly, columns (5)-(8) present the results for log SO_2 and columns (9)-(12) for the average z-score of log COD and log SO_2. In these cases, the estimates are generally not precisely estimated. But given the similar magnitude to that using satellite data, it seems difficult to assume that these effects are zero. These results would look more precisely estimated when clustering the standard errors at the governor level or province-year level. But I would like to be more conservative and keep them clustered at the province level.

Past/Future Connections To check whether the findings are specific to connections with the current PSC members (who make the promotion decision), columns (1)-(2) of Table B.2 present a horse-race test between connections with the current PSC members and connections with the past/future PSC members. As shown, the link between connections and pollution is indeed specific to being connected with those in power, consistent with the promotion results in column (6) of Appendix Table B.1.

Since connections with the past/future PSC members can also capture general eliteness of a politician, this result suggests that my findings are closely related to the promotion channel rather than some general feature of being an elite politician.

The Number of Connections Instead of using a dummy indicating connections, columns (3)-(4) of Table B.2 present the results using the number of connections linearly. They also show a significant impact of the number of connections on pollution (measured by AOT). As expected, the magnitude is slightly smaller than that using the connection dummy.

Excluding the North Plain Figure 2 shows that a few provinces in the North Plain (Shanxi, Shandong, Henan, and Tianjin) have more connected observations. To make sure my findings are not driven by these specific provinces, I exclude them and find that the baseline results are only marginally changed (reported in columns (5)-(6) of Table B.2).

Considering Party Secretaries As explained above, I focus on governors because they were in charge of the economy. My findings are robust to considering the political connections of party secretaries. In fact, I do not find any strong link between the latter connections and pollution, as shown in Table B.3.

4.4 Precipitation, Connections and Coal-fired Power

The case of electricity generation is useful in two aspects. First, it is a sector with two distinct technologies, coal-fired power and hydropower, where the former is known as the culprit for pollution. Second, precipitation provides exogenous variation for me to examine the substitution between the two technologies. This also partially addresses the endogeneinty concern of connections: now, I examine how connected governors respond to the shocks differently from their non-connected counterparts. Specifically, I run a within-province estimation as follows:

$$\ln \text{CoalPower}_{igt} = \beta C_{igt} \times \text{Less}_{it} + \beta_C \text{C}_{igt} + \beta_{Less} \text{Less}_{it} + \text{X}'_{igt}\gamma + \text{Less}_{it} \times \text{X}'_{igt}\nu + \alpha_i + \lambda_t + \varepsilon_{ijt}. \quad (3)$$

The specification is similar to the baseline specification (1). As in models studying interactions, I allow the impacts of controls to differ by precipitation by including $\text{Less}_{it} \times \text{X}_{igt}$. Alternatively, I also allow the impacts of controls to differ by connections by including $\text{C}_{igt} \times \text{X}_{igt}$.

Column (1) of Table 6 shows the negative impact of log precipitation on coal-fired power production, which confirms that precipitation matters for electricity generation. Column (2) presents the dummy indicting less precipitation (with a level below the 75th percentile) is associated with 3.5% more coal-fired power production. As discussed above, this dummy is defined widely to ensure enough observations in the cell of "being connected–having less precipitation". Column (3) presents the interaction effect of connections and less precipitation. Column (4) includes all the controls in Table 2, while columns (5)-(6) further add $\text{Less}_{it} \times \text{X}_{igt}$ and $\text{C}_{igt} \times \text{X}_{igt}$ respectively. They show that conditional on less precipitation, connected governors increase coal-fired power by about 13%, three to four times the average effect.

These findings provide further support for the connection-pollution link. Moreover, it shows that production technology employed by connected governors can indeed be different. Of course, this is not the only channel through which career concerns work, as it is only one example of many policies governors can influence.[20]

5 Other Possible Channels

The results above are consistent with the interpretation that connections increase the marginal returns of pollution and consequently affect pollution. However, connections may also affect pollution through other channels. I discuss two important possibilities here. One is whether connections bring more resources from the center directly; the other is whether connections protect politicians from being punished due to pollution.

Additional Resources from the Center A large political economy literature (mentioned in the introduction) has documented that connections bring more resources for the clients. In my context, it is possible that connected governors get more resources from the center so that they produce more and pollute more. My previous findings show that connections increase pollutants even after controlling for production. In addition, the finding on coal-fired power production indicates that the connected governors' behavior is also affected. Nevertheless, it is interesting in itself to investigate the link between connections and additional resources

[20]If I examine very broad categories such as agriculture vs. industry, I do not find that connections have significant impacts on the their relative importance in GDP. However, there could exist switches among more specific industries.

from the center.

The first measure of resources from the center is the net fiscal transfers – the transfers from central governments to local governments subtracting the transfers the other way around (Lin 2011). The data are obtained from *China Finance Yearbooks*. Columns (1)-(2) of Appendix Table B.4 show that there is no significant correlation between connections and log transfers. Naturally, these data come from official sources and suffer from similar concerns as the official measures of pollution. However, unlike the relative stable and sizable estimates on pollution, the coefficients are not stable and small in magnitude.

Another measure is an important form of industrial policies that is usually considered as help from the center, namely special economic zones (Wang 2013, Alder et al. 2016). I find connections increase neither the number of new special economic zones (columns (3)-(4)) nor the share of special economic zones relative to the number of prefectures in a province (columns (5)-(6)).

Thus, I have not found any notable effect of connections on direct resource allocation. However, these results are not intended to deny that connections can bring more resources. For instance, in the case of coal-fired power discussed in Section 4.4, it is possible that connected governors are more likely to apply and get permission from the center to increase power production. However, it is difficult to disentangle this demand effect (due to career concerns) from the supply effect (of direct resource allocation). The bottom line of my findings is that connections can affect the incentives of politicians and this effect can be intertwined with favors because incentives affect the demand for favors.

Different Punishment Probability My main findings suggest that connections are of importance for the outcomes of pollution because they affect the likelihood of promotion and hence politicians' behavior. I interpret connections as an accelerator. However, a different interpretation related to the mechanism of career concerns is that connections work as protection. For example, the promotion probability of connected politicians may be less likely to decrease even if they pollute more. In the conceptual framework, this channel implies that connections decrease the costs of pollution rather than increase the returns from output.

To see whether this alternative channel is critical, I examine the interaction effects of connections and pollutant (COD and SO_2) growth on pollution. Different from the results on connections and growth in Appendix Table B.1, neither the interaction of connections and COD growth (columns (1)-(2)) nor the interaction of connections and SO_2 growth (columns (3)-(4)) matters for promotion (presented in Table B.5). One explanation is that the yearly change in pollution rarely affects the career of politicians unless there are severe accidents. Moreover, column (5) shows that the finding on the interaction effect between real GDP growth and connections still holds after considering connections and pollution growth.

Therefore, while this alternative channel is reasonable conceptually, I do not find it to be critical empirically. But once again, one could argue that these results cannot fully capture the possible lenient regulatory environment for connected governors. Like the discussion above on help from the center, it is possible that career concerns and a lenient regulatory environment work together.

6 Conclusion

This paper provides a political logic to explian China's pollution problem during 1993–2010. Using both satellite and official data, I document the positive link between political connections and pollution in China. Further, I present evidence supporting the notion that this connection-pollution relationship is in line with the influence of political connections on the incentives that drive politician behavior.

My research highlights a key policy insight: Modifying political incentives is a potent tool for addressing environmental issues. This approach is exemplified by recent measures in China. Since 2013, the central government has shifted its focus away from linking economic growth with official promotions, reducing reliance on environmentally harmful technologies to boost growth. This shift is evidenced by policy declarations like "GDP should not be the main criterion for official promotion,"[21] Furthermore, in 2015, concurrent with the "War on Pollution" campaign, many local governments began to associate environmental protection with career advancement. While my research findings on the influence of promotional incentives on pollution may not fully align with the latest data, the conceptual framework I discuss remains pertinent and valid. Indeed, it could be argued that these political incentives have been pivotal in both the escalation of China's pollution crisis in my period of focus (1993–2010) and its subsequent progress in combating pollution.

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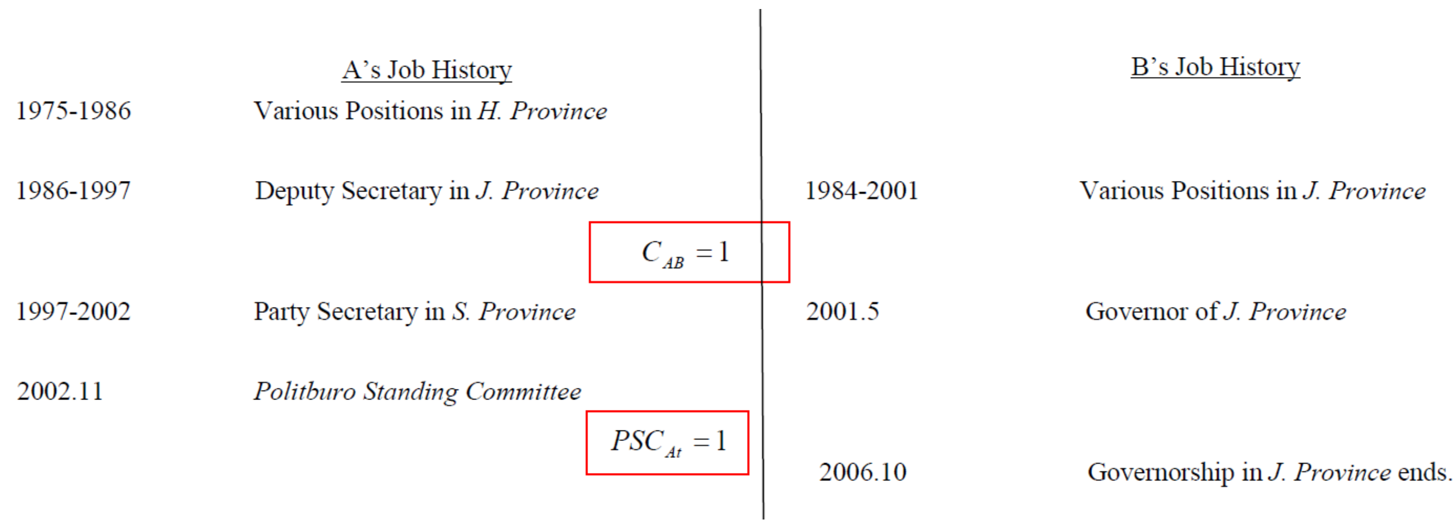
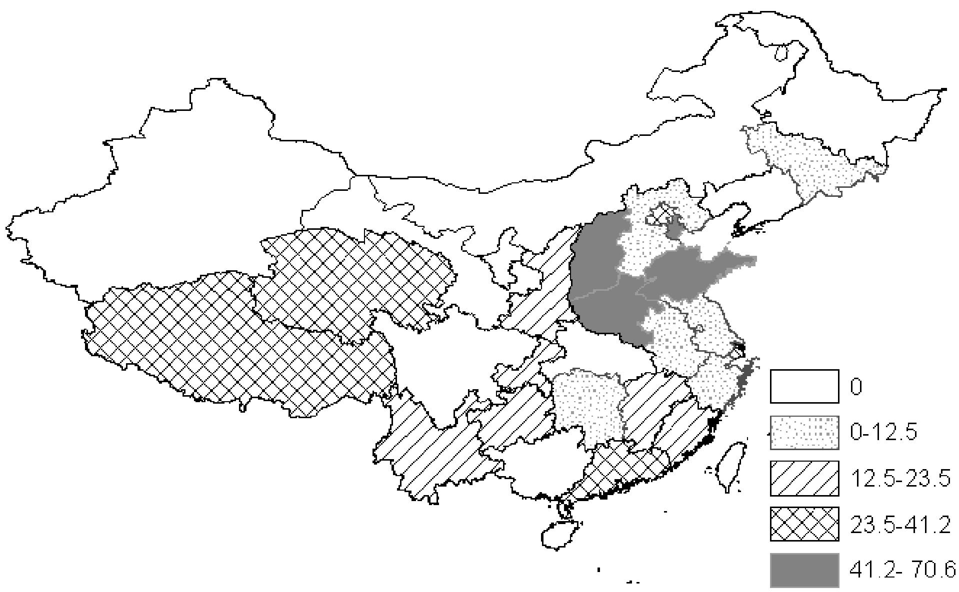
Figure 1: Definition of Connections



Notes: This figure gives an example of connections. A and B worked together in the 1980s and 1990s ($C_{ij} = 1$). B was a governor in Jiangxi Province between 2001 and 2006 while A became a PSC member in November, 2002. Therefore, B was not connected to the PSC between 2001 and 2002 but got connected since 2003.

Figure 2: Spatial Distribution of Connections



Notes: This figure maps the mean of connections in a province between 1993 and 2010. No systematic pattern exists about the assignment of connected leaders. This does not imply no endogeneity in assignment but suggests that the bias due to endogenous appointment may not work toward one direction. The map also shows that the provinces in the North Plain (Shandong, Shanxi, Henan, and Tianjin) are more likely to be connected. I exclude these provinces for robust checks.

Table 1: Summary Statistics

Variable	Obs.	Mean	Standard Dev.	Min	Max	source
(a) Connections and Promotion						
Connection (0/1)	447	0.19	0.39	0	1	1
#Connections	447	0.23	0.52	0	2	1
Promotion	447	0.098	0.298	0	1	1
Average growth since assuming office	447	0.115	0.025	0.054	0.209	2
(b) Control Variables						
Ave. real GDP growth in 3 preceding years	447	0.11	0.03	0.05	0.26	2
ln real GDP	447	6.78	1.07	3.71	9.21	2
ln Population	447	5.77	0.81	3.84	6.87	2
Age	447	57.70	4.07	43	66	1
College education	447	0.83	0.37	0	1	1
Served in the center	447	0.35	0.48	0	1	1
Ruling birth province	447	0.38	0.49	0	1	1
Second Term	447	0.12	0.32	0	1	1
(c) Pollution Outcomes						
AOT (province-month data)	29180	1.57	1.00	0.04	10.94	3
ln COD (province-year data)	447	11.75	1.11	7.98	14.00	4
ln SO2 (province-year data)	447	3.69	0.99	0.51	5.17	4
(d) Coal-fired power production						
ln (Coal-fired Power)	447	5.81	1.01	2.72	7.95	5
ln Precipitation	447	4.31	0.64	2.69	5.64	6
Connection & Less Abundant Precipitation	447	0.13	0.34	0	1	1,6

Data Sources:
1: http://chinavitae.com.
2: Comprehensive Statistical Data for 60 Years of New China.
3: NASA: http://gdata1.sci.gsfc.nasa.gov/daac−bin/G3/gui.cgi?instanceid=aerosolmonthly.
4: China Environment Yearbooks.
5: China Electricity Yearbooks.
6: NOAA: http://www.cpc.ncep.noaa.gov/products/globalprecip/html/wpage.cmap.html.

Table 2: Correlation with Other Provincial and Individual Characteristics
Dependent Var.: Connections (0/1)

	(1)	(2)	(3)	(4)	(5)	(6)
	across-province			within-province		
Average real GDP growth in 5 preceding years			0.664			-1.274
			(0.921)			(1.083)
Average real GDP growth in 3 preceding years		0.598			-0.620	
		(0.808)			(0.874)	
Real GDP growth in the preceding year	0.662			0.048		
	(0.677)			(0.679)		
ln real GDP	0.128***	0.128***	0.127***	-0.044	0.002	0.050
	(0.032)	(0.033)	(0.034)	(0.298)	(0.303)	(0.306)
ln Population	-0.089**	-0.089**	-0.088**	0.548	0.485	0.429
	(0.037)	(0.037)	(0.037)	(0.462)	(0.465)	(0.467)
Age	-0.019***	-0.019***	-0.019***	-0.018***	-0.018***	-0.018***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
College	-0.083*	-0.082*	-0.080*	-0.021	-0.017	-0.018
	(0.048)	(0.048)	(0.048)	(0.051)	(0.051)	(0.051)
Served in the center	0.022	0.020	0.019	0.071*	0.078*	0.087**
	(0.039)	(0.039)	(0.040)	(0.040)	(0.041)	(0.042)
Ruling birth province	-0.152***	-0.153***	-0.153***	-0.084*	-0.081*	-0.079*
	(0.038)	(0.038)	(0.038)	(0.047)	(0.047)	(0.046)
Second term	0.066	0.065	0.065	0.037	0.035	0.033
	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)
Year FE	Y	Y	Y	Y	Y	Y
Province FE				Y	Y	Y
Observations	447	447	447	447	447	447
R-squared	0.221	0.220	0.220	0.413	0.414	0.415

Notes: The table presents the correlations between the connection dummy and other provincial and individual characteristics. Connections are positively correlated with age and having served in the center, negatively correlated with ruling one's birth province. I control for these characteristics in the analysis of the connection-pollution link.

Table 3: Connections and Pollution – Results using monthly satellite data
Dependent Var.: standardized AOT

	(1)	(2)	(3)	(4)	(5)	(6)
Connection	0.126***	0.116***	0.106***	0.130***	0.129**	0.169***
	(0.043)	(0.036)	(0.034)	(0.039)	(0.048)	(0.052)
Governor FE				Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y
Year FE, Month FE	Y	Y	Y	Y	Y	Y
Controls		Y	Y		Y	Y
East/West*Year FE			Y			Y
Observations	29,180	29,180	29,180	29,180	29,180	29,180
R-squared	0.325	0.326	0.330	0.331	0.331	0.335

Notes: This table shows that gaining connections increases pollution measured by satellite data. Columns (1)-(3) use within-province variation and column (4)-(6) use within-governor variation. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.

Table 4: Year-by-Year Results on Connections and AOT
Dependent Var.: standardized AOT

	(1)	(2)	(3)
Reference: 3+ years before			
2 years before connection	0.052	0.023	0.029
	(0.058)	(0.059)	(0.054)
1 year before connection	0.054	0.060	0.096
	(0.085)	(0.087)	(0.075)
1st year of being connected	0.171**	0.167**	0.179**
	(0.083)	(0.077)	(0.074)
2nd year of being connected	0.127	0.100	0.130*
	(0.079)	(0.083)	(0.071)
3+ years of being connected	0.127	0.097	0.121
	(0.087)	(0.087)	(0.081)
Province FE	Y	Y	Y
Year FE, Month FE	Y	Y	Y
Controls		Y	Y
East/West*Year FE			Y
Observations	27,352	27,352	27,352
R-squared	0.232	0.312	0.313

Notes: This table shows that the significant correlation between connections and AOT only occurs after gaining connections, suggesting that there are no systematic pre-trends. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.

Table 5: Connections and Pollution – Results using yearly official data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent Var.	ln COD				ln SO2				z-score of ln COD and ln SO2			
Connection	0.146	0.192	0.127***	0.106*	0.100	0.125	0.084	0.058	0.124	0.160	0.107**	0.082
	(0.172)	(0.151)	(0.036)	(0.054)	(0.089)	(0.085)	(0.055)	(0.058)	(0.128)	(0.115)	(0.044)	(0.049)
Governor FE			Y	Y			Y	Y			Y	Y
Province FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls		Y		Y		Y		Y		Y		Y
Observations	447	447	474	447	447	447	474	447	447	447	474	447
R-squared	0.871	0.891	0.975	0.975	0.950	0.954	0.991	0.991	0.920	0.931	0.987	0.987

Notes: This table presents the association between connections and official pollutants. They are generally not precisely estimated. But the magnitudes are similar to those in Table 3. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.

Table 6: Precipitation, Connections and Coal-fired Power
Dependent Var.: ln Coal-fired Power

	(1)	(2)	(3)	(4)	(5)	(6)
Less Precipitation*Connection			0.129*	0.137*	0.284***	0.136**
			(0.074)	(0.067)	(0.083)	(0.059)
Connection			-0.051	-0.063	-0.186**	0.839
			(0.056)	(0.062)	(0.068)	(0.644)
Less Precipitation		0.035*	-0.008	-0.025	-2.719*	0.007
		(0.020)	(0.038)	(0.053)	(1.452)	(0.046)
ln Precipitation	-0.198**					
	(0.080)					
Province FE, Year FE	Y	Y	Y	Y	Y	Y
Controls				Y	Y	Y
Controls*Less Precipitation					Y	
Controls*Connection						Y
Observations	447	447	447	447	447	447
R-squared	0.970	0.968	0.969	0.970	0.974	0.972

Notes: This table shows that less precipitation increases the production of coal-fired power and the impact is larger for the connected governors. Less precipitation is a dummy indicating that the precipitation level is lower than the 75th percentile. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.

A A Simple Model

A.1 Setup

Technology The Local Governor G_L can produce output Y by using a dirty input (E), a clean input (K) and a third factor such as land or labor (L). Of course, in the real world, politicians do not choose production technology but choose policies that affect the technology choices of firms.

The production function is as follows:

$$Y = E^{\alpha} K^{\beta} L^{1-\alpha-\beta},$$

where $\alpha+\beta < 1$.[22] The dirty input (E) generates pollution. This is a shortcut to think about the policy instruments of G_L. In the real world, G_L can choose policies such as environmental regulations that affect the technology choices of firms. For simplicity, I assume L to be fixed and equal to 1. Thus, the production function can be rewritten in logs:

$$y \equiv \ln Y = \alpha \ln E + \beta \ln K.$$

The choice of G_L is subject to his budget:

$$pE + K = e,$$

where the price of K is normalized to 1 and the relative price of E is p.

G_L can increase his budget (e) by putting in more effort. Effort is costly, with an increasing cost function Ae, where A is a positive constant.[23] If a higher output increases the promotion probability, G_L would like to use more dirty input E for a given a level of e. However, pollution has an additional cost of BE, where B is a positive constant. The cost can reflect the fact that G_L dislikes pollution like any other citizen or because pollution leads to some punishment.

The final observed log output also depends on G_L's competence θ:

$$\widetilde{y} = \theta + \alpha \ln E + \beta \ln K, \tag{4}$$

[22] I use the Cobb-Douglas production function following a literature on environmental economics (Copeland and Taylor 2004). By assumption, there is a complementarity between E and K. All results below hold if I assume that E and K are perfect substitutes. Using the Cobb-Douglas production function simplifies my calculations.

[23] The linear cost function is assumed for simplicity. The results are robust to using a convex cost function but the expressions are less transparent.

where θ has a normal distribution with mean $\overline{\theta}$ and variance σ_θ^2. As I use log transformations for ease of algebra, θ can be considered as a productivity shock to y.

Note that − like in the Holmström (1999) career concerns world − G_L also does not observe θ when he takes the decisions. As discussed in Persson and Tabellini (2000), this avoids issues of signaling but leads to similar conclusions as in the case where G_L observes θ. The assumption that G_L does not know his ability can be considered as him not being certain about his ability to run the province. Thus, he also needs output information to update his own belief. The technology choices of local governors are also assumed to be not verifiable to the Central government. This assumption can be relaxed by allowing for additional noise in observed output where connections can also affect the noisiness.

Promotion Rule The promotion rule is determined by the Central Government (G_C). The payoff that G_C can get from G_L is complementary in $G_L's$ competence (θ) and connection (C). I assume that what G_C can get is given by the expected value $\mathbb{E}(q(C)\theta)$, where $q'(C) > 0$. I set $q(C) = C$ so that I do not need to carry around $q'(C)$ in the calculation. One interpretation can be that G_L might hide a certain part of the production (positively associated with G_L's competence) from G_C but connected governors hide less. Jia et al. (2015) model the role of C with three possibilities: C affects the marginal returns, the information on output and the information on governors' ability. Here, I focus on the channel of marginal returns as a reduced-form way to capture the complementarity between growth and connection.

G_L gets promoted if the expected utility from promoting him for G_C exceeds the expected utility from promoting an average governor. Denote the expected utility $\underline{U}$.[24] The promotion can be written as:

$$\mathbb{E}(C\theta) \geq \underline{U} \tag{5}$$

where connection (C) can be observed by G_C. In contrast, G_C cannot observe $G_L's$ competence, θ. Instead she infers θ from the noisy signal $\ln y$. Thus, the promotion rule can be rewritten as:

$$C\mathbb{E}(\theta|\widetilde{y}) \geq \underline{U}.$$

Since $\mathbb{E}(\theta|\widetilde{y}) = \overline{\theta} + \widetilde{y} - \mathbb{E}\widetilde{y}$, the promotion probability is defined by the following

[24] In this setup, I focus on whether G_C decides to promote one governor compared to the expected utility from promoting an average ($\underline{U}$). Yardstick competition is not considered here. Allowing for yardstick competition generates a similar conclusion on the incentives but has different implications on the equilibrium chance of promotion. This promotion rule also implies that governors function as politicians who want to satisfy the key officials in the Center rather than as bureaucrats who maximize $\mathbb{E}(\theta|y)$ in a labor market with many potential employers (Alesina and Tabellini 2007).

condition:

$$P = \Pr\left(\theta \geq -y + \mathbb{E}y + \frac{\underline{U}}{C}\right) = 1 - \Phi\left(-y + \mathbb{E}y + \frac{\underline{U}}{C}\right), \tag{6}$$

where $\Phi(\cdot)$ is the c.d.f of the normal distribution with mean $\overline{\theta}$ and variance σ_θ^2.

Promotion Incentives and Connection In equilibrium, $\mathbb{E}y = y$, and the promotion probability will be:

$$P = 1 - \Phi\left(\frac{\underline{U}}{C}\right). \tag{7}$$

This condition implies that a connected G_L is more likely to be promoted. Further,

$$\frac{\partial P}{\partial y} = \phi\left(\frac{\underline{U}}{C}\right). \tag{8}$$

$\phi(\cdot)$ is the p.d.f of the normal distribution with mean $\overline{\theta}$ and variance σ_θ^2. For $P < \frac{1}{2}$,[25] this condition implies that the marginal effect of GDP on promotion is higher for a connected G_L.

In this paper, I focus on the *upward* (promotion) incentives for politicians, as provincial governors have a promising career where the returns to promotion are high. In the real world, some governors may also care about private rents that breed corruption in environmental regulation. Such *downward* (corruption) incentives are relatively more important for politicians that have little hope of moving upward such as those in charge of a specific sector.

Timing Before finding the solution, let me clarify the timing of events. First, G_L chooses E and K, knowing his own connections C but not his ability θ. Second, nature picks θ. Output is realized and observed (augmented by θ) by G_C. Last, observing the output, G_C decides whether to promote G_L. If G_L is promoted, G_C gets $C\theta$ from him. If an average candidate is promoted, G_C gets $\underline{U}$.

A.2 Solution

The problem for G_L is to maximize the expected benefits from promotion minus the cost of pollution (with the benefit from promotion being normalized to 1):

$$P \cdot 1 - Ae - BE,$$

[25] This assumption is reasonable, given that the mean promotion rate is 0.10 in the data.

s.t.

$$E + pK = e.$$

where $P = 1 - \Phi\left(-y + \mathbb{E}y + \frac{U}{C}\right)$.

Note that G_C can dislike pollution more than G_L. However, given that E is not verifiable for G_C, whether E is in G_C's utility function or not does not change the solution to G_L's problem. Besides, the costs of E in G_L's utility imply that pollution does not directly affect the promotion probability P. Some empirical support for this implicit assumption is presented in Section 5.

Substituting the budget constraint into the maximization equation, the first-order conditions can be written as follows:

$$MR_E \equiv \phi(\frac{\alpha}{E} - \frac{\beta p}{e - pE}) = MC_E \equiv B, \tag{9}$$

$$MR_e \equiv \phi\frac{\beta}{e - pE} = MC_e \equiv A, \tag{10}$$

where $\phi \equiv \phi(\frac{U}{C})$ indicates the density of competence, while $(\frac{\alpha}{E} - \frac{\beta p}{e-pE})$ and $\frac{\beta}{e-pE}$ indicate the marginal returns from E and e in terms of increasing output.

The two first-order conditions give the equilibrium level of E and K:

$$E^* = \frac{\alpha\phi}{pA + B} \equiv \alpha\phi\widetilde{p}, \tag{11}$$

where $\widetilde{p} \equiv \frac{1}{pA+B}$ can be considered as (a transformation of) the price of K relative to E (rather than the other way around).

Comparative Statics Since $\phi_C > 0$ (given that $P < \frac{1}{2}$), the comparative statics of the equilibrium condition for E in equation (11) give the following prediction:

P1 *Connection (C) has a positive impact on emissions (E): $\frac{\partial E}{\partial C} > 0$. Moreover, the impact of connection (C) on emissions (E) is more than proportional to the impact on the production if $\alpha + \beta < 1$.*

The second part of the prediction can be seen by the following calculations. Rewrite the production function in terms of E^* and K^* ($Y = (E^*)^\alpha (K^*)^\beta = (\phi\alpha\widetilde{p})^\alpha (\frac{\phi\beta}{A})^\beta$) and divide E by Y ($E = \phi\alpha\widetilde{p}$) to get:

$$\frac{E(C)}{Y(C)} = \phi(C)^{1-\alpha-\beta}(\alpha\widetilde{p})^{1-\alpha}(\frac{\beta}{A})^{-\beta}.$$

A second prediction regards the substitution between the two technologies:

P2 *Not only does the relative price of the clean input ($\widetilde{p}$) raise E:* $\frac{\partial E}{\partial \widetilde{p}} > 0$*, but this effect is increasing in* C: $\frac{\partial^2 E}{\partial \widetilde{p} \partial C} > 0$.

As the proof is straightforward, I intuitively discuss the mechanisms at work. Given that the promotion probability is less than $\frac{1}{2}$, $\phi_C > 0$, i.e., a higher level of C increases the value of a given unit of marginal output in terms of expected promotion and, consequently, increases the effort e as well as the use of dirty input E.[26] Different from C, a higher price of the clean input ($\widetilde{p}$) increases the marginal returns from the dirty input and hence makes the dirty input more attractive. This substitution channel itself is quite mechanical. More interestingly, the substitution effect is further strengthened by G_L's career concerns (affected by C), which drives an interaction effect of $\widetilde{p}$ and C.

B Additional Empirical Results

[26] It is worthwhile to mention that the impact of connections on E is positive but smaller for a fixed level of effort e. Now suppose that e is fixed. Taking the derivative with respect to C in equation (9) gives: $\frac{\partial E}{\partial C} = \frac{\alpha \phi_C - \frac{\beta p E}{e - pE} \phi_C}{\beta \phi p \frac{e}{(e-pE)^2} + B}$. In the case where e is endogenous, equation (9) and equation (10) give the following condition: $\frac{\partial E}{\partial C} = \frac{\alpha \phi_C}{\beta \phi p \frac{1}{e - pE} + B}$. Clearly, the right-hand side in the former case is smaller (with a smaller nominator and a larger denominator) but it is also positive (the sign can be seen from the first-order condition). This comparison shows that there is an additional effect of connections on pollution by putting in more efforts.

Table B.1: Empirical Support for the Key Assumption
Dependent Var.: Promotion (0/1)

	(1)	(2)	(3)	(4)	(5)	(6)
Connection * Real GDP Growth			3.574*	4.054**	3.514**	3.726*
			(1.784)	(1.765)	(1.690)	(1.976)
Real GDP Growth		0.861	0.525	-0.321	-24.504	0.009
		(0.623)	(0.531)	(0.714)	(15.058)	(0.971)
Connection	0.058	0.058	0.024	0.021	0.025	0.017
	(0.037)	(0.036)	(0.034)	(0.036)	(0.038)	(0.037)
Past/Future Connection *Real GDP Growth						-1.411
						(1.754)
Past/Future Connection						0.007
						(0.033)
Province FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Controls				Y	Y	Y
Controls * Growth					Y	
Observations	447	447	447	447	447	447
R-squared	0.163	0.165	0.172	0.199	0.213	0.201

Notes: This table presents support for the key assumption in my conceptual framework: connections and growth performance are complements in promotion. Real GDP growth refers to the average annual growth since assuming office. Jia et al. (2015) provide more robustness checks on this pattern. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.

Table B.2: Additional Robustness Checks
Dependent Var.: standardized AOT

	(1)	(2)	(3)	(4)	(5)	(6)
Robustness Checks	Past/Future Connections		Number of Connections		Excluding the North Plain	
Connection	0.133***	0.118***			0.130***	0.082***
	(0.047)	(0.041)			(0.039)	(0.027)
Past/Future Connection	0.025	0.006				
	(0.042)	(0.034)				
#Connections			0.090***	0.081***		
			(0.031)	(0.027)		
Province FE, Year FE	Y	Y	Y	Y	Y	Y
Controls		Y		Y		Y
Observations	29,180	29,180	29,180	29,180	26,459	26,459
R-squared	0.325	0.326	0.325	0.326	0.322	0.317

Notes: This table presents three sets of robustness checks. Columns (1)-(2) show that the link between connections and pollution are restricted to the connections with the current PSC members. Columns (3)-(4) present similar results using the number of connections instead of the connection dummy. Columns (5)-(6) show that the baseline is robust to excluding four provinces in the North Plain. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.

Table B.3: Results for Party Secretaries

	(1)	(2)	(3)	(4)	(5)	(6)
Connection	0.013	0.016	0.015	0.026	0.039	0.072
	(0.023)	(0.020)	(0.022)	(0.036)	(0.038)	(0.056)
Governor FE				Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y
Year FE, Month FE	Y	Y	Y	Y	Y	Y
Controls		Y	Y		Y	Y
East/West*Year FE			Y			Y
Observations	29,465	29,465	29,465	29,465	29,465	29,180
R-squared	0.322	0.323	0.327	0.329	0.329	0.333

Notes: This table presents the estimates for the connections of party secretaries. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.

Table B.4: Other Mechanisms – connections and resource allocation

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var.	ln Net Transfer from Center		#SEZs		Share of SEZs	
Connection	-0.022	0.031	-0.109	-0.161	-0.005	-0.009
	(0.057)	(0.038)	(0.108)	(0.123)	(0.007)	(0.008)
Province FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Controls		Y		Y		Y
Observations	423	423	474	447	474	447
R-squared	0.957	0.974	0.236	0.289	0.198	0.245

Notes: This table examines whether connections affects the transfers and industrial policies (measured by special economic zones) from the center. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.

Table B.5: Other Mechanisms – connections as protection
Dependent Var.: Promotion (0/1)

	(1)	(2)	(3)	(4)	(5)
Real GDP growth * Connection					2.714*
					(1.452)
COD growth * Connection	0.017	0.028			0.063
	(0.076)	(0.081)			(0.112)
SO2 Growth * Connection			-0.285	-0.323	-0.242
			(0.243)	(0.263)	(0.507)
Connection	0.041	0.042	0.026	0.026	0.017
	(0.031)	(0.035)	(0.035)	(0.038)	(0.033)
COD growth	-0.056	-0.070			-0.086
	(0.075)	(0.082)			(0.103)
SO2 growth			0.042	0.037	0.069
			(0.090)	(0.102)	(0.123)
Real GDP growth					0.156
					(0.708)
Province FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Controls		Y		Y	Y
Observations	415	415	415	415	415
R-squared	0.164	0.193	0.162	0.191	0.198

Notes: This table shows that the interaction between pollution growth and connections is not significantly correlated with promotion. Controls are the variables listed in column (2) of Table 2. Reported in parentheses are standard errors clustered at the province level. * Significant at 10%, ** 5%, *** 1%.