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. Guided by a simple career concerns model, I examine empirically how promotion incentives of provincial governors affect pollution. To find exogenous promotion incentives, I explore within-governor variation in connections with key officials due to reshuffling at the center and document the fact that connections are complementary to economic performance for governors' promotion. The data confirms the model prediction that connections increase pollution. Auxiliary predictions of the model are also confirmed by the data.

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1 Introduction

How do political incentives affect the environment? 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. Politicians can also be attracted by rents offered by private firms in exchange for tacit permission to conduct environmentally harmful economic activities. Gobal Witness (2012) reports that officials and private companies in Liberia have colluded to secure logging permits and cut down pristine forests. Despite many real-world cases, research on the political economy of the environment is still very sparse. This paper offers evidence from China based on various sources of data and demonstrates that high environmental pollution levels can partly be explained by politicians' incentives.

China is, in many ways, 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), is among the worst in the world. Across China, only 1% of urban dwellers breathe 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 some common features with industrialized societies when they were less developed. But relative to its developmental stage, China has relied on an unusually high amount of polluting industries (Vennemo et al. 2009). The reason is generally suspected to be political: abundant anecdotal evidence 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. 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 document that in

[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.

[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

the data, connections and economic growth are complements for promotion. Based on this empirical finding, I assume complementarity between connections and performance in the model: connections increase the marginal value of economic performance. This complementarity also implies that connections increase the marginal values of dirty technologies and effort. As a result, the model 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. The simple model also delivers two auxiliary predictions. First and unsurprisingly, a higher relative price of clean technologies increases the use of dirty technologies due to a substitution effect. However, connections further strengthen the substitution effect because of their complementary role in promotion. Second, under the standard assumption that the production technology has decreasing returns to scale in the two types of technologies, the model predicts that the impact of connections on pollution is more than proportional to their impact on production.

These predictions are then taken to a data set across 30 Chinese provinces between 1993 and 2010.[5] Two main empirical challenges are data quality and identification. The data-quality challenge, which is general for studies on the political economics of contemporary China, is that the data might be subject to gaming by politicians. To address this challenge, I first employ satellite information on Aerosol Optical Thickness (AOT), a measure highly correlated with pollution.[6] Then I use official data on two major pollutants, namely Chemical Oxygen Demand (COD) in industrial waste water (measured data) and industrial SO_2, a major pollutant in the air (reported data). The paper also employs data from various other sources, including biographies of politicians open to the public, provincial-level outcomes from official yearbooks, firm-level data from industrial censuses, as well as weather shocks from the US National Oceanic and Atmospheric Administration (NOAA). This way, I can examine the impacts of career concerns with different lenses and check for consistency of findings based on different data sources.

The identification challenge is to find exogenous variation in political connections. A provincial leader is defined as connected if at least one of his past colleagues entered the Politburo Standing Committee (which decides on the promotion of provincial leaders) due

governors is more important.

[5]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. The promotion outcomes for provincial officials are available between 1993 and 2009.

[6]Chen et al. (2012) evaluate the quality of the official pollution index data at the city level. Linking city-level index with satellite information, they find that the official data have useful information on pollution, despite some bunching related to blue sky standards.

to a reshuffling at the center. But connections are not necessarily exogenous. For example, 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. To find exogenous variation in connections, I focus on *within-governor* variation: I examine how governors respond to gaining or losing connections due to the reshuffling of the Politburo Standing Committee, given that they have already been appointed. This way, I can address the endogenous appointment concern that has been discussed yet often unsolved.[7] The advantage of this strategy is that the variation is very likely to be exogenous. The disadvantage is that I employ the variation of a small sample. Therefore, I compare within-governor estimates to within-province estimates and find that they are not dramatically different in magnitudes but the within-province estimates are generally less precise.

To test the first model prediction, on the link between connections and pollution, I investigate province-level information on three measures of pollutants: AOT (satellite information), COD (measured data in official yearbooks) and SO_2 (reported data in official yearbooks). Connections increase both AOT and COD significantly and the magnitudes are comparable: around 11% of one standard deviation. The impact of connections on industrial SO_2 is less precise (with a magnitude of 8%).

To test the second model prediction, related to the interaction of connections and the relative price of inputs, I focus on the electricity-generation sector. In China, two main technologies produce electricity: coal-fired thermal power is dirty and hydro power is clean. When droughts limit the use of water, hydro power becomes relatively more expensive. This creates a testing ground for my model. I find that droughts indeed increase coal-fired power use by about 3% and that connections further strengthen the impact of droughts: the interaction of connections and droughts further increases coal-fired power by about 6%.

To check the third model prediction, i.e., that the effect of connections on pollution is more than proportional to production, I examine the impact of connections on GDP as well the correlations between GDP and pollutants. If a scale alone explains the previous findings, one would expect that the effect on GDP would account for the results on pollutants. Additionally, I also control GDP in the estimates. Both ways suggest that the effect of connections on pollution goes beyond a scale effect.

The different sources of data deliver a similar message: connections increase the marginal payoff of pollution, i.e., strengthen the career concerns of politicians. However, connections might capture other dimensions. In particular, two other channels may work together with

[7]For example, as pointed out by Huang (1999), "instead of monitoring the specific tasks that local officials perform, the central government carefully monitors political and professional credentials when they make personnel selections".

career concerns. First, connected governors might be protected so that they can pollute more. I do not find this to be the case in the data. Second, connected governors may get more resources from the center and hence, pollute more. I present evidence that transfers from the center cannot explain all my findings. This is not to deny the role of favoritism but to provide evidence that connections can also affect the career prospective of politicians. Moreover, I also present further evidences to support the interpretation of career concerns. In particular, I show that the effect of connections on COD is relatively weaker for the old cohort. Since the old cohort has fewer promotion opportunities, this evidence provides further support for the career-concerns channel.

Although it is not surprising that connections and performance can be complements in many contexts, this role of connections has not been empirically documented. Existing studies on the value of political connections have focused on favoritism (Fisman 2001; Shih 2004; Khwaja and Mian 2005). Different from these studies, I show that connections may also affect the effort and policy choices of politicians. If the connections of politicians in China only worked through a favoritism channel, the outcomes would be very inefficient. In contrast, if the connections of politicians also lead to more efforts and more pro-growth policies (despite the multi-tasking distortions of different dimensions of efforts), we see positive effects on economic growth.[8] This might be one reason why a society like China, where connections play a critical role in business and politics can still grow fast.

Besides the studies of political connections, this paper is also related to a few other lines of literature. First, it is an addition to the meager literature on the political economy of the environment (e.g., List and Sturm (2006) on how election incentives affect environmental policies in the US and Burgess et al. (2012) on how private incentives of local politicians increase the deforestation in Indonesia).[9] In terms of external validity, the finding that politicians are strongly motivated by promotion might be specific to China. However, the implication that political incentives affect the environment is general.

Second, it 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 (Besley and Case 1995). Empirically, it is not easy to find exogenous variation in

[8]This feature has a similar flavor to the multitasking model in Holmström and Milgrom (1991).

[9]Recent studies have showed correlations between environmental protection and promotion and have not reached any conclusion. Wu et al. (2012) shows 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. In contrast, Zheng et al. (2013) find that environmental protection is positively correlated with the promotion of mayors.

career concerns and existing studies focus on the lame-duck effect due to term limits. This paper provides another perspective to the study of career concerns.

Third, in the context of China, an emerging literature in economics argues that career concerns play an important role in promoting growth, as provincial leaders are incentivized by the prospect promotion. Due to the political structure that each province does not only enjoy a certain degree of autonomy but is also self-contained in its functions, it is also feasible for provincial leaders to enhance growth once they are incentivized. This line of empirical literature finds that higher economic growth increases the probability of promotion (Li and Zhou 2005). Xu (2011) summarizes related studies. The finding is not uncontroversial, as social connections are considered to be a critical factor for promotion stressed in the political science literature.[10] Thus, the question is whether growth still matters for promotion once social connections have been accounted for (Opper and Brehm 2007; Shih et al. 2012). In a related paper, my coauthors and I provide systematic evidence on the complementarity between connections and growth for promotion (Jia et al. 2012). The present study instead focuses on one important consequence of promotional incentives: the environment.

Finally, existing studies on the political economy of contemporary China have also examined the impact of other characteristics of politicians, particularly the impact of inside versus outside politicians on local capture (e.g. Persson and Zhuravskaya 2012). This characteristic does not vary within individuals. This paper studies the impact of political characteristics that may vary over time. The emprical strategy has a similar flavor to that in Blanes i Vadal et al. (2011) which explores within-lobbyist variation to evaluate the impact of connections on revenues of lobbying firms.

The paper is organized as follows. Section 2 lays out a theoretical framework of career concerns and pollution, which guides the empirical specifications. Section 3 describes the institutional background and the data. Section 4 presents the main empirical strategy, the empirical tests of the three main predictions of the model as well as several robustness checks. Section 5 further discusses the mechanism of connections. Section 6 concludes the paper.

2 Theoretical Framework

To guide my empirical analysis, I present a model with three key elements and present empirical support for the key assumptions.

First, there is a positive link between career concerns and output. This feature is shared

[10] There is also a literature on factionalism in Chinese politics contributed by political scientists such as Nathan (1973), Dittmer (1995), Shih (2004), Bo (2007), and Shih et al. (2012). More closely related to this paper, Cai and Traisman (2006) speculate that growth-enhancing policies emerged from competition between pro-market and conservative factions in the central government.

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). Third, variations in career concerns are allowed. I model this feature as different social connections to the key officials in the Center. This feature is specific to this paper and has empirical underpinnings. An empirical test of this assumption is discussed in Section 2.3.

With these three features, in the model, a Local Governor (G_L) is motivated by career concerns to satisfy the Central Government (G_C). Different from the standard career-concerns model, I examine how 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 social connections.

2.1 Model Assumptions

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. Here, I take reduced-form way to model policy choices.

The production function is as follows:

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

where $\alpha+\beta < 1$.[11] 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:

$$y \equiv \ln Y = \alpha \ln E + \beta \ln K. \tag{2}$$

The choice of G_L is subject to his budget:

$$pE + K = e, \tag{3}$$

[11] 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.

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. Efforts are costly, with an increasing cost function Ae, where A is a positive constant.[12] 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:

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

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 (see Jia et al. (2012) for more extensions of the model).

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. Empirical support for the complementarity assumption is presented in Section 2.3. Naturally, one can imagine that C and θ are substitutes. If C and θ were substitutes, the implications would be opposite to the solution presented below.

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 $\underline{U}$.[13] The promotion

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

[13]In this setup, I focus on whether G_C decides to promote one governor compared to the expected utility

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:

$$C\mathbb{E}(\theta|\widetilde{y}) \geq \underline{U}. \tag{6}$$

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

$$P = \Pr\left(\theta \geq -y + \mathbb{E}y + \frac{\underline{U}}{C}\right) = 1 - \Phi\left(-y + \mathbb{E}y + \frac{\underline{U}}{C}\right), \tag{7}$$

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:

$$P = 1 - \Phi\left(\frac{\underline{U}}{C}\right). \tag{8}$$

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

$$\frac{\partial P}{\partial y} = \phi\left(\frac{\underline{U}}{C}\right). \tag{9}$$

$\phi(\cdot)$ is the p.d.f of the normal distribution with mean $\overline{\theta}$ and variance σ_θ^2. For $P < \frac{1}{2}$,[14] 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.

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).

[14]This assumption is reasonable, given that the mean promotion rate is 0.13 in the data.

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 $\underline{U}$.

2.2 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):

$$P \cdot 1 - Ae - BE, \tag{10}$$

s.t.

$$E + pK = e. \tag{11}$$

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

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. I provide empirical support for this implicit assumption in Section 2.3.

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

$$MR_E \equiv \phi(\frac{\alpha}{E} - \frac{\beta p}{e - pE}) = MC_E \equiv B, \tag{12}$$

$$MR_e \equiv \phi\frac{\beta}{e - pE} = MC_e \equiv A, \tag{13}$$

where $\phi \equiv \phi(\frac{\underline{U}}{C})$ 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:

$$E^* = \frac{\alpha\phi}{pA + B} \equiv \alpha\phi\widetilde{p}, \tag{14}$$

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 (14) give the following two predictions:

P1 *Connection (C) has a positive impact on emissions (E):* $\frac{\partial E}{\partial C} > 0$.

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.[15] 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.

What is the impact of connections on E relative to the scale of production Y? This 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:

$$\frac{E(C)}{Y(C)} = \phi(C)^{1-\alpha-\beta}(\alpha\widetilde{p})^{1-\alpha}(\frac{\beta}{A})^{-\beta}. \tag{15}$$

Equation (15) gives the following prediction:

P3 *The impact of connection (C) on emissions (E) is more than proportional to the impact on the production scale.*

This prediction follows because $\alpha + \beta < 1$ (together with $\phi_C > 0$), a standard assumption about the production function. This assumption is also reasonable in this context, as the inputs are often subject to certain capacity constraint. For example, the increasing demand for coal makes coal mining deeper and deeper.

[15] 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 (12) 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 (12) and equation (13) 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 of equation (15) 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.

2.3 Discussion of the Assumptions

A key assumption for Prediction 1 and Prediction 2 is that connections and performance are complementary for promotion. Also, by assumption, connections and pollution together does not directly affect the promotion probability. These assumptions revolve around the promotion outcome, which constitutes the focus of Jia et al. (2012). Here, I present some statistical support for the assumptions. Specifically, I examine how promotion is affected by GDP and pollutant growth, connections as well as the interaction of the two factors. I discuss these empirical findings now, in close connection with the model − even though I have not yet introduced the underlying data. These data will be carefully discussed in the next section, however.

Table 1 presents the main results on promotion for governors using data between 1993 and 2009. 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.[16] In line with the underlying literature, GDP growth is measured the average annual real GDP growth since assuming office. In Jia et al. (2012), we find that networks between former work colleagues matter the most for promotion. Thus, I use this definition of connections.

[Table 1 about here]

Column 1 shows that connections are positively correlated with promotion. The connection effect is large: the connection dummy increases the promotion probability by around six percentage points whereas the 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). It is also the implication of equation (8) above. Column 2 reports the effects of growth and connections together. The coefficient of GDP growth is positive but is not significant after clustering standard errors at the politician level. This finding can be taken as a robustness check of the argument in the related economics literature such as Li and Zhou (2005). Column 3 presents the interaction effect of growth and connections. Column 4 includes regional trends and column 5 further includes characteristics of governors, showing that the results in column 3 are stable across specifications.[17] These findings shed some

[16]See Jia et al. (2012) 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.

[17]These characteristics include whether the politician has been in office longer than one term (to capture potential lame-duck effects), his age, his education (college or not), whether he is from the province he governs and whether he has work experience in the central government.

light on the debate whether performance is of importance for promotion. They suggest that performance and connections are complementary and provide an empirical underpinning for the complementarity assumption made in my model.

Similarly, columns 6-9 present the results on how the growth of major pollutants and their interactions with connections affect promotion.[18] The interaction has no significant impact on promotion. These results provide support for the assumption that (year-to-year) pollution has no direct impact on promotion. This is not surprising given that pollution may affect promotion only when it leads to extreme accidents.

3 Institutional Background and Data

To test Predictions 1 and 3 empirically, I combine information on provincial governors and data on provincial-level pollutants based on satellite data and official data. To focus on the governors who are most likely to affect economic outcomes, I exclude those who hold office for less than two years in the baseline estimates and include them as robustness checks. Connection C is defined from politicians' careers. To test Prediction 2, I focus on the electricity-generation sector and examine the interaction effect of connections and droughts, as droughts affect the relative price of coal-fired power and hydro power. Since the use of my data hinges on institutions, I now combine a discussion of institutional background with a description of data.

3.1 Province-level Outcomes

Satellite data: AOT Corresponding to E in the model, I first look at Aerosol Optical Thickness (AOT) information provided by NASA. 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 and control for both region and month fixed effects. The mean of AOT in the data is 0.21 and the standard deviation is 0.14. To be able to compare with the results using official data, I normalize the dependent

[18]The number of observations is smaller than those using GDP growth. This is because the pollution data can only be traced back to 1993 and hence pollution growth since assuming office is not available for a few governors.

variable by its standard deviation. Summary statistics are presented in Panel A of Table 2. The advantage of this information is that it is not subject to the manipulation concern. The limitation is that it is not available before 2000.

Official Data: COD and SO_2 I look at two major pollutants in each province i and year t: Chemical Oxygen Demand (COD) in industrial waste water and industrial Sulfur Dioxide (SO_2). Both of them are known from the literature on the impacts of pollution to be detrimental to health and land productivity.[19]

The source of these data is *China Environment Yearbooks,* available between 1993 and 2010.[20] 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 the log of COD are 11.73 and 1.12 whereas those for the log of SO_2 are 12.91 and 0.99. Summary statistics are presented in Panel A of Table 2. To be comparable with the results from satellite AOT, I also normalize them by their standard deviations in the empirical analysis. However, since the standard deviations are close to 1, the coefficients can also be interpreted as growth in COD and SO_2.

GDP To test the prediction that the impact of connections goes beyond a scale effect, I also look at the ratios of pollutants over production. To measure production, I use official information on GDP. The data is gathered from *Comprehensive Statistical Data for 60 Years of New China* for the years between 1993 and 2008 and from *China Statistical Yearbook* for the years 2009 and 2010. As in Panel A of Table 2, the mean and standard deviation of the log of GDP are 8.07 and 1.15.

[19]COD in industrial waste water is known to be positively correlated with liver cancer and digestive cancers such as gastric cancer (Zhao et al. 2012). Besides the direct health impact, a large share of China's irrigation water is waste water, where a higher level of COD has a negative impact on land productivity as well as a negative indirect health impact via crops (*The New York Times* 2007). Industrial SO_2 is significantly correlated with chronic obstructive pulmonary diseases in some parts of China (Xu et al. 2000). In addition to its adverse impact on health, SO_2 is also the main cause of the acid-rain problem, a serious threat to agricultural productivity (Xing 2002).

[20]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.

3.2 Connections of Provincial Governors

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. The results for party secretaries are presented in Table A2 the appendix.[21] 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).[22] Hence, I mainly exploit the connections with the PSC members.[23] 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 "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 governors, party secretaries 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

[21] 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).

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

[23] Connections with non-standing members do not have significant impact on promotion, as shown in Jia et al. (2013).

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., $\#C_{ijt} = \sum_j \mathcal{I}(C_{ij} * PSC_{jt} > 0)$. 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.

Figure 1 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 govenors as Xinjiang and Qinghai in the west. This does not to deny endogenous appointment but suggests that the bias due to endogenous appointment may not necessarily work toward one direction.

[Figure 1 about here]

In the period between 1993 and 2010, the PSC has been reshuffled in three congress years (1997, 2002 and 2007), which creates variations for PSC_{jt} and hence for C_{ijt}. Two points regarding the PSC reshuffling are worth clarifying. First, there is a combination of anticipation and uncertainty about the PSC members. The President and Prime Minister positions are predictable as these people are usually members of the previous PSC. There is much more uncertainty about the remaining of the members. For example, two politicians who were predicted by various media to have the highest probability of joining the PSC failed to do so in the recent reshuffling of 2012.[24] Despite potential anticipation, this study focuses on the impact of being connected with people in power. Second, since the congress took place in October or November, the actual reshuffling years are 1998, 2003 and 2008.

Among my 474 governor-year observations, 356 are never connected, 58 have one or two connections which remains the same throughout the governorship while 60 have variations within a given governor. If I focus on the connection dummy rather than the number of connections, 47 observations have within-governor variations. Summary statistics of connections and other characteristics of politicians are presented in panel B of Table 2. Table A2 in the appendix presents summary statistics of observable characteristics for the three groups of governors. It shows that governors who are always connected have shorter tenure and are less likely to govern their home province, suggesting that their appointment may be endogenous. In contrast, the switchers and those never connected are not very different in these observables. I also control these characteristics in the empirical analysis.

[24] An example of guesses and predictions can be found at http://chinese-leaders.org/blog/predictions-and-guesses-for-chinas-5th-generation-politburo-standing-committee.

My 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). It allows me to control for politician fixed effects, which is critical to address the concern of endogenous appointments.

3.3 The Case of Electricity Generation

Coal-fired Power Prediction 2 of the model involves the relative price (p) of clean and dirty inputs. To bring this prediction to the data, one needs to consider a certain production sector. The electricity-generation sector provides a natural testing ground for two reasons.

First, the electricity market in China is not integrated. Because electricity is critical for production, it and 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 (hydro power). Among China's provinces excluding Tibet, 28 out of 30 use both technologies (the two exceptions are Tianjin and Shanghai where hydro power is not available). In 2010, coal-fired power accounted for 80.3% of the total electricity power whereas the hydro power accounted for about 18.4%. Nuclear, wind and other sources together only have a share of 1.3%. Coal-fired thermal 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.[25] 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 droughts occur (*Life News* 2010). Droughts naturally make the relative price of hydro power higher and hence, make coal-fired power more attractive.

Provincial-level coal-fired power production is measured in 10^4 kilowatt hours. The data source is *China Electricity Yearbooks*. As shown in Panel B of Table 2, the mean and standard deviation of the log of coal-fired power are 5.87 and 1.02.

[25] 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.

Droughts Droughts (D_{it}) are defined from rainfall data. Provincial-level rainfall data is aggregated from monthly grid-level information with ArcGIS, provided by the Climate Prediction Center Merged Analysis of Precipitation (CMAP) at NOAA, available for 28 provinces between 1993 and 2010. The grid-level information in this database does not cover Beijing and Tianjin. I first sum the twelve 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. My binary drought dummy is set at 1 rather than 0 if and only if when $\ln(\text{Rainfall})$ in a given year is less than the provincial mean between 1993 and 2010 minus one standard deviation.[26] As shown in Table 2, 16% of the province-year observations have droughts.

4 Empirical Strategy and Baseline Results

4.1 Empirical Strategy

The connection variable (C_{ijt}) is defined based on job history (i.e., C_{ij} is based on historical information) and its variation comes from the reshuffling in the center (i.e., from PSC_{jt}). This way of defining connections allows me to address different sources of endogeneity. The first endogeneity challenge is that governor i might like to build a connection for his career. This may happen in the real world but is not the focus of this paper. My definition avoids this concern as connections are based on historical information.

A second challenge is that connected governors may be appointed to certain regions, e.g. provinces that can develop relying on cleaner technologies. As I focus on *within-governor* variation, i is already a governor. Thus, this concern is relieved.

A remaining challenge is that member j's entry into the PSC may be affected by i's performance. This concern is very unlikely in this context because politicians are often rotated in China. In the subsample with within-governor variation, none of the j entered PSC immediately after i took the governorship. In other words, after i and j shared a workplace, j either took a position in another province or in the central government. Later, I also allow for a dynamic specification to check for this concern.

The main estimation strategy is similar to a differences-in-differences (DD) strategy, where I compare the impact of connections before and after getting connected, within the same governor. The baseline estimates always control for province and year fixed effects. These fixed effects control for all time-invariant differences between provinces and time-

[26]The rainfall data is available since 1979. Droughts can also be defined according to the mean and standard deviation of data between 1979 and 2010. Using this definition generates similar results to those presented below.

variant changes that affect all provinces similarly. Moreover, I control for governor fixed effects and exploit within-governor variation.

The main specification is as follows:

$$E_{ijt} = \mu_j + \beta_C C_{ijt} + X'_{ijt}\gamma + \alpha_i + \lambda_t + R_i\lambda_t + \varepsilon_{ijt}, \quad (16)$$

where E_{ijt} is pollution outcomes (normalized by their standard deviations) under the administration of governor j in province i and year t (or in a given month when using monthly satellite data). Further, α_i indicates province fixed effects. λ_t indicates year fixed effects (and also month fixed effects when using monthly satellite data); C_{ijt} the connection dummy indicating whether governor j in province i is connected to a PSC member in year t; X_{ijt} is a vector of controls including whether the governor has been in office longer than one term, his age, his education (college or not), whether he is from the province he governs and whether he has work experience in the Central government. Naturally, time-invariant governor characteristics are redundant after including governor fixed effects. I use tenure non-linearly because age and tenure are co-linear within a governor. This also helps to control for potential lame-duck effect.

Meanwhile, I control for regional-specific (nonparametric) trends 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 governor level.[27]

4.2 Baseline Results

4.2.1 Testing P1: the Impact of Connections on Pollution

In specification (16), β_C is the parameter of interest. Prediction 1 states that connections increase pollution, i.e., $\beta_C > 0$. Now I show the results for different measures of E_{ijt}.

Results Using Monthly Satellite Data (2000-2010) Table 3A presents the results for monthly AOT (normalized by its standard deviation). Column 1 shows the results controls for province, year and month fixed effects. Column 2 also includes controls while

[27]The main results are robust to clustering at the province level. But the number of clusters is very limited given that there are only 30 provinces.

column 3 further includes region-specific trends. These within-province estimates show that connections increase AOT by about 11% of its standard deviation.

Columns 4-6 present the corresponding results from within-governor estimations. Column 7 also includes those in office for less than two years. The magnitudes are close to those from within-province estimations. However, it is worthwhile pointing out that the similarity in magnitudes does not imply no endogenous appointment concerns. Instead, it suggests that potential endogeneity in appointment does not necessarily bias the estimates toward the same way. For example, promising politicians can be assigned to both coastal provinces and western regions. This implication is consistent with the message from Figure 1.

[Table 3A about here]

[Table 2 about here]

Results Using Yearly Official Data (1993-2010) Table 3B shows the results using $\ln \text{COD}$ (normalized by its standard deviation) as the dependent variable.[28] After clustering the standard errors, the within-province coefficients are not very precisely estimated but the magnitudes are not far from the within-governor estimates: connections increase industrial COD by about 9%-11% of the standard deviation of the dependent variable. Given that the standard deviation of $\ln \text{COD}$ is 1.12, this implies that connections increase industrial COD by about 10%. These results are comparable to those using satellite data.

[Table 3B about here]

Similarly, Table 3C shows the results using $\ln SO_2$ as the dependent variable. The message is similar: connection increases industrial SO_2 by about 7% from both within-province and within-governor estimations (the standard deviation of $\ln SO_2$ is 0.99). However, compared with those for COD, the coefficients are smaller and less precisely estimated. This may not be surprising given that the information on SO_2 comes from reported data, which suffers more from quality concerns than the information on COD.

[Table 3C about here]

There has been technological progress across the country over time. On average, the amounts of industrial COD and SO_2 emissions in a province are decreasing over time. The

[28] Note that AOT is not logged but COD and SO_2 are logged. The specification in each column corresponds to that in in Table 3. This is because they are measured in very different ways. AOT is a variable with small mean (0.21) and standard deviation (0.14) whereas COD and SO_2 are measured in thousands of tons.

finding that connections increase pollution can be interpreted as evidence that they make the decrease in pollution smaller.

In general, the comparison of the results using satellite data and official data has three implications. First, results using official data are less precise than using satellite information. Second, within official data, COD works better than SO_2. Third, the consistency in magnitudes of the three measures that official data do contain useful information. Besides, official data have two other advantages: it is available for a longer period so that I can examine dynamic impacts and I can link them with other provincial outcomes such as GDP and transfers from the central government. Table A2 in the appendix present the results for the connections of party secretaries, which shows that those connections have no impact on pollution. As explained in the institutional background, this is because their major responsibilities include the implementation of the central government policies and social stability whereas governors' key duty is to promote growth.

4.2.2 Testing P2: Droughts, Connections and Coal-fired Power

I focus on the electricity generation sector to test prediction 2 of the model. I do not have data on regional electricity prices or prices on coal-fire power and hydro power. Instead, I explore exogenous droughts shocks to the relative price between hydro power and coal-fire power. Droughts naturally make coal-fired power more attractive. Moreover, the model predicts that connections strengthen the impact of droughts.

To test this prediction, I run a within-governor estimation as follows:

$$\ln \text{CoalPower}_{ijt} = \mu_j + \beta \text{C}_{ijt} \times \text{D}_{it} + \beta_C \text{C}_{ijt} + \beta_D \text{D}_{it} + \text{X}'_{ijt}\gamma + \text{D}_{it} \times \text{X}'_{ijt}\nu + +\alpha_i + \lambda_t + R_i\lambda_t + \varepsilon_{ijt}. \quad (17)$$

The specification is similar to the baseline specification (16). As in models studying interactions, I also include the interaction of droughts and controls ($\text{D}_{it} \times \text{X}_{ijt}$). This is to address the concern that the impact of droughts might be heterogeneous, contingent on different controls. The results are presented in Table 4.

Column 1 shows the negative impact of rainfall on coal-power use. Column 2 shows that droughts increase the use of coal power by about 3%, which confirms the the definition of droughts is reasonable. Column 3 presents the interaction effect: the interaction of connections and droughts increases the coal power use by about 5.7%. Column 4 includes controls as well as their interactions with droughts. Column 5 further includes region-specific trends. Column 6 also includes hydro-power production. The coefficients are stable across these specifications.

[Table 4 about here]

These results suggest that connections increase the response of coal-fire power to droughts from about 3% to about 9%. The mean of province-year coal-fired power use is around 55 Twh. Thus, a 9% increase implies an amount of 150 ($55 \times 30 \times 9\%$) Twh, which is close to the entire amount of electricity power produced in Sweden during an average year.

It is conceivable that the interaction effect is larger in regions where hydro power is more important. To examine the heterogeneous effects, I separate the sample by the median share of hydro power relative to coal-fired power (the median value is 16%). Note that the share in a few provinces change from below the median to above or vice versa. Column 7 reports the results for those above the median whereas column 8 presents the results for those below the median. As they show, the impact is more important for regions with hydro power share above the median.

4.2.3 Testing P3: Beyond the Scale Effect

The model predicts that the impact of connections on pollution may go beyond a scale effect. I use two ways to check whether this is the case. First, I present some estimates on the magnitude of the scale effect. Second, I include production scale as a control variable to see whether the impact on pollution still remains.

First, I compare the reduced-form estimates. Columns 1-2 in Table 5A show that connections increase COD by about 10% and SO_2 by about 8% (This is consistent with results in Table 3B and 3C. Recall that the standard deviations of the logs of COD and SO_2 are 1.12 and 0.99 respectively). Column 3 shows that connections increase GDP by about 4% (not significant). If a scale effect alone accounts for the impact of connections on pollution, we expect that the elasticity of pollution with respect to GDP should be above 2. Columns 4-5 show that the correlations between GDP and COD as well as SO_2 in the data are 0.8 and 0.6 respectively, which are much smaller than 2. This suggests that a scale effect alone cannot explain the previous findings.

[Table 5A about here]

Second, I also control for GDP in the estimations. The results are presented in Table 6. Columns 1-2 show the results for COD after controlling for GDP. Once again, the impact of connections on COD survives. Moreover, column 3 uses the ratio of COD to GDP and shows that the ratio is also increased by connections. Columns 4-6 present the corresponding results for SO_2, These effects are positive but not significant.

[Table 5B about here]

4.3 Robustness Checks

In this subsection, I show the results from three robustness checks. First, to deal with the concerns of pre-trends, I allow for more dynamic flexible specifications to examine the impact of gaining a connection. Second, to deal with potential support from the center, I examine the impact of connections on transfers from the center and control for transfers. Finally, as a measurement check, I use the number of connections linearly instead of the connection dummy.

The Dynamic Impacts of Connections Equation (16) 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_{ijt}. Among the observations that have switches within a given governor, the majority of them gain a connection.[29] Hence, I look at the dynamic effects of gaining one more link by estimating the following regression:

$$E_{ijt}= \mu_j+\sum_{\tau=-n}^{\tau=+m}\beta_\tau \mathrm{C}_{ij(t_0+\tau)}+\mathrm{X}'_{ijt}\gamma+\alpha_i+\lambda_t+\varepsilon_{ijt}, \tag{18}$$

where t_0 presents the transition year and τ flags the years before and after t_0.

Limited by the data, I cannot estimate a long-horizon dynamics. I use the transition year as the default period and compare it with the years before getting connected, the first year of gaining connections as well as more than (or equal to) two years after gaining connections. To have a slightly larger sample of switchers, the transition year is defined based on the number of connections and the results also hold if it is defined according to the connection dummy.

The results are presented in columns 1-4 of Table 6. An impact of connections is seen after getting connected. The magnitudes are similar to the baseline estimates. The finding that β_{-1} is not different from 0 also shows that the anticipation of future appointments PSC members does not play a significant role. This finding suggests that being in power matters the most for the incentives. After connection switch happens in year t, the impact takes place in $t+1$ or $t+2$. The short time lag suggests that governors would like to grab the opportunity quickly, since the average length in office is only around four years. This is also feasible given the institutional background of regional decentralization, where provincial leaders enjoy autonomy to a large extent (see Xu (2011) for more discussions).

[29]There are two reasons why the number for losing connections is smaller than that for gaining connections. First, the number of Politburo Standing Committee Members increased from seven to nine. Second, the number of connections increases over time as the political system becomes more stable – the younger cohorts are more likely to have experience of local governments at various levels before becoming governors.

In addition, column 5-6 present for the GDP and show a similar dynamic pattern to that for pollutants: the impact of connections take action after one or more periods. The results in columns 2,4 and 6 are visualized in Figure 2. The solid lines indicate the coefficients and the dashed lines indicate the 95% confidence intervals.

[Table 6 about here]

[Figure 2 about here]

Controlling for Transfers from the Center One concern is that the provinces with connected governors might get more resources from the central government, grow faster, and pollute more. This interpretation implies that the pollution and GDP growth difference stems from redistribution.

Given the finding in Section 4.2.3 that connections also increase pollutants even after controlling for production, the concern about more help from the central government is not that critical. Even if connected politicians get more transfers from the central government, which increase the scale of the economy, this cannot explain all of the previous findings.

However, it might be interesting in itself to check for the link between connections and favors and examine whether connections still are still of importance once transfers from the central government is controlled for. This is feasible, given the information on the fiscal budget of provincial governments. To measure favors from the center, I use the transfers from central governments to local governments subtracting the transfers the other way around. This data is from *China Finance Yearbooks* and is available between 1994 and 2010. Columns 1 in Table 7 show that the correlations between connections and the log of transfers are positive but not significant. Columns 2-5 show the results after controlling for transfers, which are a bit smaller than the baseline estimates. Transfers clearly cannot account for all the effect of connections.

[Table 7 about here]

Using the Number of Connections The baseline estimations use a dummy to indicate connection. Now I use the number of connections linearly. Before examining its impact on pollution, I check whether its impact on promotion is consistent with the complementarity finding using the connection dummy. These results are presented in Table A3 in the appendix. The results are consistent with the baseline estimates: there is a robust complementarity. As expected, the impact of the number of connections is smaller compared with the results using the connection dummy.

Table 8 presents the results using the number of connections. To be comparable to results in tables 3B and 3C, the dependent variables are the logs of COD and SO_2 normalized by their standard deviations. Columns 1-3 show the results for COD and columns 4-6 show the results for SO_2. Once again, similar to the baseline estimates, the coefficients for COD are significantly positive but those for SO_2 are not significant. As expected, the magnitudes are slightly smaller than those in tables 3B and 3C.

[Table 8 about here]

5 Further Evidence on the Mechanism

Career Concerns vs. Protection The 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, in the real world, connections might also capture other dimensions. 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 theoretical framework, this implies that connections decrease the costs of pollution rather than increase the returns from output. In the real world, pollution might lead to political costs when it leads to extreme accidents. However, when it comes to yearly emissions, the impact on promotion is unclear. As already shown in Table 1 and Table A3, the interaction of connection and pollutant growth does not affect promotion. In contrast, the interaction of GDP growth and connections has a significantly positive impact on promotion. These results suggest that the protection mechanism is less important than the accelerator mechanism.

Career Concerns vs. Favoritism Both protection and acceleration can be taken as career concerns. Favoritism is very different from career concerns. As shown in Table 8, transfers from the center cannot explain my finding. It can still be argued that some favors are difficult to observe and measure. For example, it might be easier for a connected governor to construct heavily polluting factories when permissions from the central government are needed. Even in this case, pollution is induced by the *demand* for factories. Typically, governors have the decision power on what factories to construct. Moreover, it is also difficult for the favor hypothesis to explain my findings on the impact of droughts as well as the interaction of droughts and connections.

Another indirect way to say that transfers cannot explain all findings is to examine whether the effect of connections on pollution is smaller for older cohorts of politicians who have weaker career concerns than younger cohorts. Older is a dummy indicating whether a politician is above the median age (58-years-old, which is also the mean age). Limited by data, this comparison is across individuals rather than within individuals. The results are presented in Table 9. They show that the effect of connections on COD is indeed lower for the older cohort. The interaction effect of connections and the older dummy on SO_2 is also negative but not significant.

The bottom line of these 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.

[Table 9 about here]

6 Conclusions

This study adds a study of China to the literature on the political economy of the environment. The political roots of China's pollution have been well recognized by the mass media. I formalize the political logic with a simple model that highlights the link between politicians' career concerns and pollution outcomes and test the key predictions.

Two main challenges for this study are identification and data quality. For the challenge of identification, I exploit within-individual variation in political connections. Different from the favor-related channel of political connections stressed in many existing studies, the results in this paper are consistent with the interpretation that connections affect the policy choices of politicians. For the challenge of data quality, which is general to any study on contemporary China, I test the predictions of the model using various sources of data: biographies of politicians, provincial-level outcomes from yearbooks, river quality from physical measurements and weather data from US weather service.

Different sources of data suggest that the incentive scheme of politicians in China is a double-edged sword: heavily-incentivized politicians would like to promote growth but growth has its social costs such as pollution. The key to avoid choking on growth requires a broader reform of the political incentive system.

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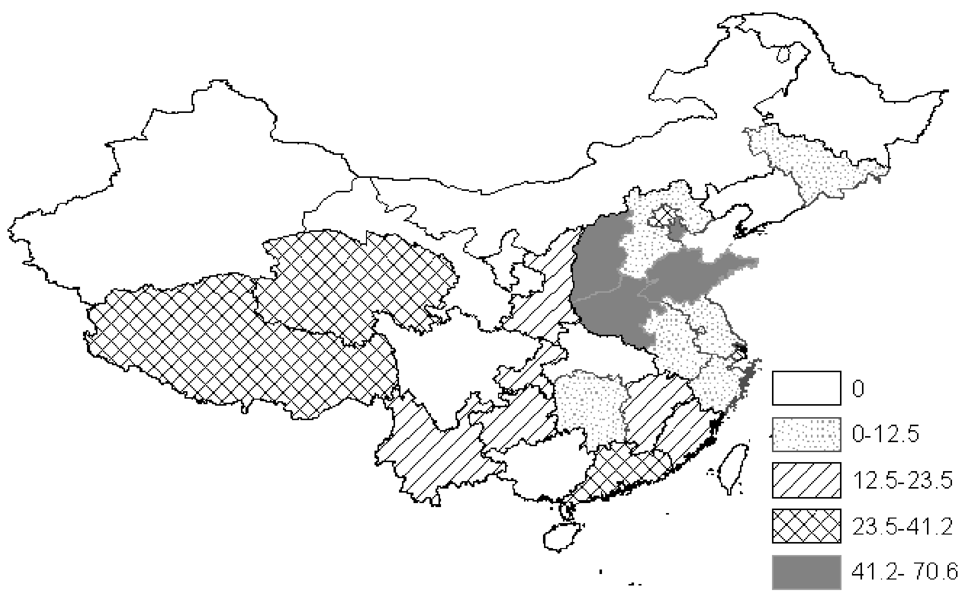
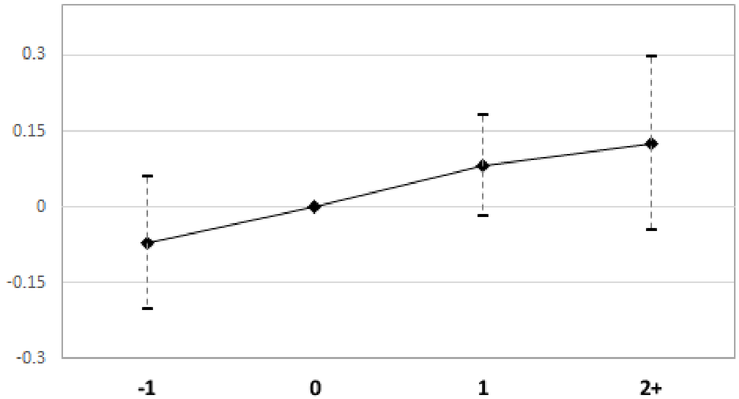
Figure 1: Spatial Distribution of Connections



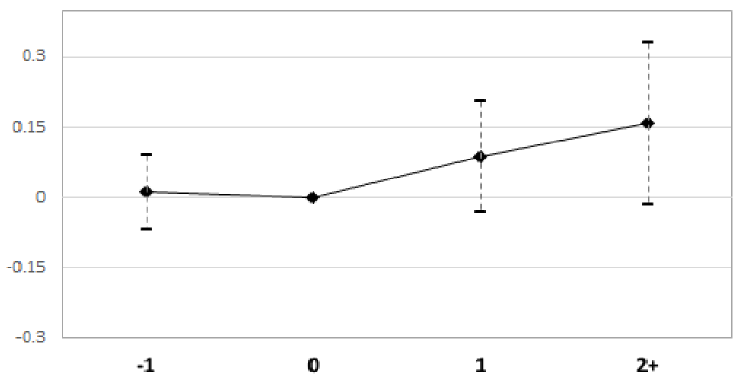
Notes: This figure maps the mean of connections in a province between 1993 and 2010. No systematic pattern exists about the assignment of connected leaders. This does not imply no endogeneity in assignment but suggests that the bias due to endogenous appointment may not work toward one direction.

Figure 2: Dynamic Impacts

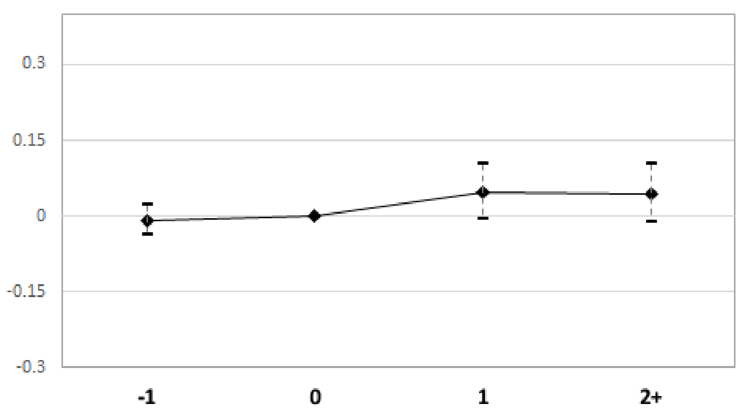
(a) COD



(b) SO2



(c) GDP



Notes: The figures visualize the results in columns 2, 4, and 6 of Table 6. They show that the impacts are discontinuous before and after gaining connections. The dotted line indicates the 95% confidence interval, with standard errors clustered at the province level. Every estimated effect is relative to the year of getting connected, which is displayed an "effect" of 0 to aid visual analysis.

Table 1: Empirical Support for the Model Assumptions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connection * D. Growth			3.574**	3.357**				
			(1.641)	(1.589)				
Demeaned GDP Growth		0.861	0.525	0.629				
		(0.625)	(0.537)	(0.562)				
Connection	0.058*	0.058*	0.024	0.027	0.041	0.040	0.026	0.026
	(0.034)	(0.033)	(0.030)	(0.033)	(0.031)	(0.035)	(0.031)	(0.034)
Connection * D. COD Growth					0.017	0.028		
					(0.086)	(0.088)		
Connection * D. SO2 Growth							-0.285	-0.297
							(0.185)	(0.198)
Demeaned COD Growth					-0.056	-0.063		
					(0.084)	(0.087)		
Demeaned SO2 Growth							0.042	0.037
							(0.086)	(0.095)
Province and Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls				Y		Y		Y
# clusters	114	114	114	114	99	99	99	99
# observations	447	447	447	447	415	415	415	415

Notes: The dependent variable is promotion. Promotion for a governor is a dummy indicating that a governor becomes a party secretary or a minister. The results are robust to using more general definitions of promotion, see Jia et al (2012). Growth measures the average of annual real growth since assuming office. Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government.
Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 2: Summary Statistics

	Mean	S.D.	Min	Max	Obs.
Panel A: Provincial-level Outcomes					
AOT[a]	0.21	0.14	0.005	1.52	32180
Log (COD)[b]	11.73	1.12	7.98	14.00	474
Log (SO2)[b]	12.91	0.99	9.72	14.38	474
Log(GDP)[c,g]	8.06	1.15	4.65	10.74	474
Panel B: Leader Characteristics					
Connection[d]	0.20	0.40	0.00	1.00	474
# Connections[d]	0.24	0.53	0.00	2.00	474
Tenure[d]	3.19	2.01	1.00	12.00	474
Age[d]	57.76	4.02	43.00	66.00	474
College graduate [d]	0.83	0.38	0.00	1.00	474
Served in center [d]	0.35	0.48	0.00	1.00	474
Ruling birth province[d]	0.38	0.48	0.00	1.00	474
Panel C: Droughts and Coal-fired Power					
Log(Coal-fired Power)[e]	5.87	1.02	2.72	8.06	474
Drought[f]	0.16	0.36	0.00	1.00	440

Data Sources:
a. NASA: http://gdata1.sci.gsfc.nasa.gov/daac−bin/G3/gui.cgi?instanceid=aerosolmonthly.
b. China Environment Yearbooks.
c. Comprehensive Statistical Data for 60 Years of New China.
d. Public Curriculum Vitae.
e. China Electricity Yearbooks.
f. NOAA: http://www.cpc.ncep.noaa.gov/products/globalprecip/html/wpage.cmap.html.
g. China Statistical Yearbooks

Table 3A: P1 - Connections and Pollution: Using Satellite data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Connection	0.125***	0.113***	0.108***	0.114***	0.116***	0.141***	0.140***
	(0.030)	(0.024)	(0.023)	(0.034)	(0.036)	(0.040)	(0.040)
Province, Year, Month FE	Y	Y	Y	Y	Y	Y	Y
Governor FE				Y	Y	Y	Y
Controls		Y	Y		Y	Y	Y
Regional Trends			Y			Y	Y
# clusters	80	80	80	80	80	80	86
# observations	32180	32180	32180	32180	32180	32180	33123

Notes: The dependent variable is AOT normalized by its standard deviation. Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Column 7 also includes those in office less than two years.
Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 3B: P1 - Connections and Pollution: Using Official COD data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Connection	0.102	0.117	0.122	0.113***	0.114***	0.089***	0.089***
	(0.112)	(0.100)	(0.098)	(0.034)	(0.033)	(0.023)	(0.023)
Province and Year FE	Y	Y	Y	Y	Y	Y	Y
Governor FE				Y	Y	Y	Y
Controls		Y	Y		Y	Y	Y
Regional Trends			Y			Y	Y
# clusters	119	119	119	119	119	119	131
# observations	474	474	474	474	474	474	489

Notes: The dependent variable is log COD normalized by its standard deviation. Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Column 7 also includes those in office less than two years.
Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 3C: P1 - Using Official SO_2 data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Connection	0.089	0.103	0.127*	0.085	0.086*	0.078*	0.078*
	(0.073)	(0.068)	(0.066)	(0.054)	(0.050)	(0.040)	(0.041)
Province and Year FE	Y	Y	Y	Y	Y	Y	Y
Governor FE				Y	Y	Y	Y
Controls		Y	Y		Y	Y	Y
Regional Trends			Y			Y	Y
# clusters	119	119	119	119	119	119	131
# observations	474	474	474	474	474	474	489

Notes: The dependent variable is log SO_2 normalized by its standard deviation. Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Column 7 also includes those in office less than two years.
Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 4: P2 - The Impact of Drought*Connections on Coal-Fired-Power

	(1)	(2)	(3)	(4)	(5)	(6)	(7) above	(8) below
Drought * Connection			0.057*	0.051*	0.058*	0.063**	0.130*	0.064
			(0.030)	(0.030)	(0.031)	(0.031)	(0.076)	(0.053)
Connection			0.025	0.038	0.088**	0.085**	0.075	0.040
			(0.044)	(0.040)	(0.044)	(0.043)	(0.073)	(0.080)
drought		0.043**	0.025	0.030	0.082	0.111	0.231	0.477
		(0.018)	(0.019)	(0.306)	(0.289)	(0.285)	(0.436)	(0.333)
Log (Rainfall)	-0.111***							
	(0.037)							
Log (Hydro Power)						-0.027	-0.234**	-0.019*
						(0.019)	(0.095)	(0.011)
Province and Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Governor FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls				Y	Y	Y	Y	Y
Drought*Controls				Y	Y	Y	Y	Y
Regional Trends					Y	Y	Y	Y
# clusters	119	119	108	108	108	108	60	56
# observations	457	457	423	423	423	423	211	212

Notes: The dependent variable is the log of coal-fired power. Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Column 7 limits the sample to those where the share of hydro power relative to coal-fired power is above the median (16%) whereas column 8 limits the sample to those below the median.
Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 5A: P3 - Comparing Reduced-form Estimates

	(1) ln COD	(2) ln SO2	(3) ln GDP	(4) ln COD	(5) ln SO2
Connection	0.099***	0.086*	0.043		
	(0.026)	(0.050)	(0.030)		
ln GDP				0.811*	0.621**
				(0.473)	(0.289)
Province and Year FE	Y	Y	Y	Y	Y
Governor FE	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y
# clusters	119	119	119	119	119
# observations	474	474	474	474	474

Notes: This table shows that a scale effect alone cannot explain the impact of connections on pollution. Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 5B: P3 - Controling for the Impact of GDP

	(1) ln COD	(2) ln COD	(3) ln SO2	(4) ln SO2
Connection	0.096**	0.097**	0.060	0.061
	(0.045)	(0.046)	(0.049)	(0.048)
ln GDP	0.734	0.729	0.581**	0.568*
	(0.472)	(0.489)	(0.283)	(0.289)
Province FE and Year FE	Y	Y	Y	Y
Governor FE	Y	Y	Y	Y
Controls		Y		Y
# clusters	119	119	119	119
# observations	474	474	474	474

Notes: Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 6: Dynamic Impacts

	(1) COD	(2) COD	(3) SO2	(4) SO2	(5) GDP	(6) GDP
1 year+ before connection	-0.071	-0.072	0.012	0.011	-0.008	-0.009
	(0.066)	(0.066)	(0.041)	(0.040)	(0.015)	(0.015)
1 year after connection	0.084*	0.082	0.092	0.088	0.050*	0.048*
	(0.050)	(0.050)	(0.061)	(0.060)	(0.027)	(0.027)
2 years+ after connection	0.125	0.125	0.157*	0.158*	0.045	0.045
	(0.087)	(0.087)	(0.090)	(0.088)	(0.031)	(0.030)
Province and Year FE	Y	Y	Y	Y	Y	Y
Controls		Y		Y		Y
# clusters	119	119	119	119	119	119
# observations	474	474	474	474	474	474

Notes: The reference year is the year of gaining connections. Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 7: Controlling for the Impact of Transfers

	(1) ln Transfer	(2) ln COD	(3) ln COD	(4) ln COD	(5) ln SO2	(6) ln SO2	(7) ln SO2
Connection	0.152	0.084**	0.085**	0.080***	0.074	0.075	0.076*
	(0.094)	(0.042)	(0.042)	(0.027)	(0.053)	(0.051)	(0.042)
ln Transfer		0.197	0.195	0.093	0.075	0.071	0.005
		(0.130)	(0.130)	(0.119)	(0.074)	(0.072)	(0.054)
Province and Year FE	Y	Y	Y	Y	Y	Y	Y
Governor FE	Y	Y	Y	Y	Y	Y	Y
Controls	Y		Y	Y		Y	Y
# clusters	114	114	114	114	114	114	114
# observations	450	450	450	450	450	450	450

Notes: Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 8: The Impact of One More Connection

	(1) COD	(2) COD	(3) COD	(4) SO2	(5) SO2	(6) SO2
# Connections	0.105	0.095***	0.094***	0.083	0.059	0.058
	(0.094)	(0.028)	(0.027)	(0.057)	(0.042)	(0.040)
Province and Year FE	Y	Y	Y	Y	Y	Y
Governor FE		Y	Y		Y	Y
Controls			Y			Y
# clusters	119	119	119	119	119	119
# observations	474	474	474	474	474	474

Notes: To be comparable to results in tables 3B and 3C, the dependent variables are the logs of COD and SO_2 normalized by their standard deviations. # Connections indicate the number of connections (varied from 0 to 2). Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

Table 9: Heterogeneous Age Effects

	(1) ln COD	(2) ln COD	(3) ln SO2	(4) ln SO2
Connection * Old	-0.372*	-0.336*	-0.064	-0.068
	(0.220)	(0.183)	(0.123)	(0.108)
Connection	0.315	0.302*	0.124	0.134
	(0.218)	(0.179)	(0.119)	(0.102)
Old	0.091	-0.086	0.024	-0.055
	(0.088)	(0.092)	(0.053)	(0.056)
Province and Year FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
# clusters	119	119	119	119
# observations	474	474	474	474

Notes: Old is a dummy indicating age over the median (58). Controls include whether a politician has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government. Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.

A Appendix: For online publication

Table A1: Comparison of Governors

	Never Connected	Always Connected	Switchers
Tenure	3.188	2.859	3.723
	(2.072)	(1.552)	(2.072)
Age	57.927	56.521	58.383
	(3.813)	(4.269)	(4.857)
Ruling birth province	0.404	0.183	0.447
	(0.491)	(0.390)	(0.503)
Served in center	0.320	0.437	0.404
	(0.467)	(0.499)	(0.496)
College graduate	0.834	0.775	0.872
	(0.372)	(0.421)	(0.337)
Observations	356	71	47

Notes: The table presents differences in characteristics between three groups of governors: those never connected, always connected and the switchers. They show that those always connected have shorter tenure and are less likely to govern their home province. The differences between switchers and those never connected are not that large in these dimensions.

Table A2: The impact of secretaries

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: AOT						
Connections of Secretary	0.013	0.009	0.014	0.013	0.022	0.063
	(0.022)	(0.019)	(0.019)	(0.033)	(0.035)	(0.047)
Panel B: COD						
Connections of Secretary	0.011	-0.022	0.031	-0.068	-0.054	0.027
	(0.089)	(0.100)	(0.097)	(0.060)	(0.065)	(0.060)
Panel C: SO_2						
Connections of Secretary	-0.021	-0.039	-0.007	-0.015	-0.024	0.052
	(0.063)	(0.067)	(0.066)	(0.055)	(0.056)	(0.057)
Province, Year, Month FE	Y	Y	Y	Y	Y	Y
Governor FE				Y	Y	Y
Controls		Y	Y		Y	Y
Regional Trends			Y			Y

Notes: This table shows that the connections of secretaries have no significant on pollution.

Table A3: The Impact of the Number of Connections on Promotion

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
# Connection * D. Growth			2.722**	2.562**				
			(1.125)	(1.128)				
Demeaned GDP Growth		0.893	0.597	0.726				
		(0.634)	(0.551)	(0.572)				
# Connection	0.046*	0.047*	0.033	0.039	0.026	0.030	0.014	0.019
	(0.028)	(0.028)	(0.024)	(0.027)	(0.025)	(0.026)	(0.025)	(0.026)
# Connection * D. COD Growth					-0.033	-0.024		
					(0.043)	(0.044)		
# Connection * D. SO2 Growth							-0.208	-0.211
							(0.204)	(0.218)
Demeaned COD Growth					-0.006	-0.014		
					(0.046)	(0.047)		
Demeaned SO2 Growth							0.036	0.030
							(0.084)	(0.093)
Province and Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls				Y		Y		Y
# clusters	114	114	114	114	99	99	99	99
# observations	447	447	447	447	415	415	415	415

Notes: Promotion for a governor is a dummy indicating that a governor becomes a secretary or a minister and promotion for a secretary is a dummy indicating that a secretary becomes a Politburo member. The results are robust to using more general definitions of promotion. Growth measures the average of annual real growth since assuming office. Controls include whether the governor has been in office longer than one term, his age, his education, whether he is from the province he governs and whether he has work experience in the Central government.
Reported in parentheses are standard errors clustered at the governor level. * Significant at 10%, ** 5%, *** 1%.