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Beyond Pollution for Promotion: Connections of Political Elites and Industrial Air Pollution in China

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Abstract

The industrial air pollution in China and mitigation efforts used to combat it may be related to the career incentives of political elites under informal institutions. This study investigates whether and to what extent the personal connections of political elites, that is, patron–client relations between local and upper-level officials, influence China's industrial pollution at the city-firm level. Our empirical analysis based on a unique data set of firm level pollution paired with information on the political elites suggests the following: local officials who have personal ties to the leader of a province tend to have more pollution-intensive enterprises under their governance; compared to foreign-owned firms, the environmental performance of domestically owned firms are more likely to be affected by these patron–client relations; and the patronage connections help local officials to better "stand in their boss's shoes," and can therefore also contribute to more mitigation of firm pollution when green growth is considered important for their career promotion. The findings of this study shed light on the political roots of pollution and its abatement and highlight the role of informal political institutions in environmental governance and pollution mitigation.

Keywords: Political connection, Pollution, Patron–client relation, Environmental management, Career incentive

JEL classification: Q5, Q53

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1. Introduction

Air pollution has become a serious environmental issue after over three decades of unprecedented economic growth in China. The heavy reliance on an energy- and pollution-intensive development path has led to a steep increase in emissions (Schreifels et al., 2012). For example, in 1998 SO2 emissions caused acid rain to cover 30% of China (Ministry of Ecology and Environment of China, 1998), and in 2006 acid rain accounted for 49% of total rainfall nationwide and almost 100% of total rainfall in 19 provinces and cities in 2006 (Meteorological Administration of China, 2007). Heavy air pollutants can result in residential health problems including cardiorespiratory diseases (Ebenstein et al., 2015), premature deaths (Lelieveld et al., 2015; Rohde and Muller, 2015), and reduction of life expectancy (Chen et al., 2013; Ebenstein et al., 2017).

After increased government reaction (Chen et al., 2013), Chinese SO2 emissions peaked in 2006 (2.59 trillion tons of SO2) and experienced a dramatic reduction afterwards (Gao, Li and Chen, 2016). In order to mitigate the heavy air pollution in China, the State Council proposed a reduction of 10% of total pollutant emissions in its 11th Five Year Plan in 2006 (State Council, 2006), which is one of the most important administrative tools in China. Starting from 2006, environmental performance has been gradually integrated into the accountability for local political leaders (Pu and Fu, 2018). In 2011, the State Council announced the National 12th Five-Year Plan for Environmental Protection (State Council, 2011), which for the first time explicitly incorporates environmental protection into the performance assessments of local government officials at all levels and implements a veto system for environmental protection. China also issued the Action Plan for the Prevention and Control of Air Pollution in September 2013 (State Council, 2013), announcing that the concentration of respirable particulate matter in all prefectures will drop by more than 10% compared with 2012 by 2017.

The causes of severe air pollution and its mitigation afterwards are closely related to political administration and the role of political elites (Bernauer and Koubi, 2009), especially in developing and transitional economies (Zheng et al., 2014; Dincer and Fredriksson, 2018; Hong and Teh, 2019). Behind the high pollution process and mitigation efforts in China, an interesting and unique phenomenon of political connections known as "Guanxi" (Shih, Adolph, and Liu, 2012; Opper, Nee, and Brehm, 2015; Jiang, 2018) attracts our attention. It helps explain the causes of both industrial pollution and subsequent mitigation efforts beyond the conventional approaches that focus on economic and technological factors (Arvesen and Hertwich, 2011; Xu, Williams and Socolow, 2009).

Personal connections of political elites, especially the patron–client relations between local and upper-level officials, constitute an integral part of the political system (Jiang, 2018). These connections profoundly impact local air pollution and environmental performance for several reasons. First, personal connections can provide lower-level officials with resources and protection from higher-level officials (Scott, 1972; Jia, 2017), which are often related to more economic production and therefore more pollution. Second, patron–client relations may act as an informal tool to align the interests and coordinate the actions of central and local officials (Jiang, 2018), which encourages pollution when economic growth is the first priority and stringent pollution mitigation when environmental protection is included in political performance assessment. Third, patron–client relations can breed corruption through lobbying or bribes (Rose-Ackerman, 1999), which can intensify air pollution through more lax environmental regulation (Wilson and Damania, 2005; Biswas et al., 2012; Candau and Dienesch, 2016; Arminen and Menegaki, 2019; Zhou, Wang, and Chen, 2020) and political protection (Fredriksson and Neumayer, 2014). In contrast to Western electoral politics, in which local political leaders are mainly responsible to their voters, Chinese local officials generated through so-called selectoral politics are instead responsible to both citizens under their governance and upper-level political leaders, highlighting the importance of patronage connections and underlining their impacts.

This study investigates how political patronage connections shape local air pollution in China. The analysis is based on evidence from China because China has not only witnessed serious environmental issues and mitigation efforts but also has pervasive political patronage connections (Jiang, 2018). The research is based on a uniquely detailed data set at the pollutant–firm–city–year level, in which each city is paired to a party secretary and a mayor. The party secretary refers to the Secretary of the Municipal Committee of the Communist Party of China, the city's first-in-command, who has political and administrative authority in policy and managerial decisions at the municipal level. The city mayor is the head of the executive branch of a city and has the responsibility of presiding over the municipal government; the mayor's political status is below that of the city secretary. The results show that local officials who have personal ties to the leader of a province tend to have more SO2 intensive enterprises under their governance. This claim is further substantiated by using both quasi-difference-in-differences (DID) analysis and the instrumental variable (IV) method in order to identify the causal relationship between political connections and pollution. We then conduct additional robustness tests on several other pollutants, as well as heterogeneity tests for different ownership and firm sizes. We find that compared with foreign-owned firms, the environmental performance of domestically owned firms are more likely to be affected by these patron–client relations. We also conduct a number of extension analyses to corroborate the main findings and to investigate the mechanisms, including reasons for appointment of local leaders to a given city (i.e., to cities with favorable conditions as a reward or to polluting cities as a test of ability), career incentives, and pollution caused by corruption. The findings of this study highlight the importance of informal institutions for environmental management and pollution mitigation.

This study contributes to the literature in three ways. First, this paper contributes to a growing literature on the political economy of the environment. By focusing on the personal connections between political elites, this study provides a better understanding of how informal political institutions affect environmental conditions and reveals the politics underlying Chinese environmental policies. Second, this study contributes to the vast literature on the relationship between career incentives for politicians and government performance. Our results show that patterns in promotion criteria have changed from sacrificing the environment in the name of economic growth to building a greener economy. It is worth noting that local officials with personal connections have responded to changes in targets even more actively than those without. Patronage connections may help local officials to better "stand in their boss's shoes" and act in a more compliant way. Personal connections between higher- and lower-level officials can "grease the wheels" and help align the targets of different levels of governments. Third, this study is based on a large unique data set that consists of disaggregated enterprise-level pollution data and paired political elite information, which allows us to identify the causality between political connections and environmental performance, and investigates several mechanisms underlying environmental performance.

The rest of this paper is organized as follows. In section 2, we review the previous literature. Section 3 details the data used in the analysis. In section 4, we outline the empirical strategy, discuss the main results, identify the causal relationships, and conduct robustness checks and heterogeneity tests. In section 5, we conduct a number of extension analyses to investigate the mechanisms behind Chinese pollution governance and environmental conditions, including resource mechanisms, career incentives, and pollution resulting from corruption. Section 6 offers the conclusions and implications for future policy.

2. Literature Review

Environmental issues have attracted a great deal of attention from academics, creating a growing body of literature on the political economy of the environment (Thomas, Timmons, and JoAnn, 2011). In particular, political connections and environmental pollution has become an emerging topic of significance (Jia, 2017). Here, we review two topics of literature: the political economy of pollution and the patronage connections between politicians.

2.1The Political Economy of Pollutions

The major focus of this study is the political economy of pollution (List and Sturm, 2006; Robin et al., 2012; Kahn, Li, and Zhao, 2015; Lipscomb and Mobarak, 2017; Jia, 2017; He, Wang, and Zhang, 2020). As a result of investigations of the political economy of connections by economists (Krueger, 1974), political connections have been viewed as both a "helping hand" that brings additional resources to enterprises and a "grabbing hand" that forces firms to overinvest in high-pollution industries to ensure economic growth, both of which result in overinvestment and increased pollution (An et al., 2016; Ling et al., 2016; Pan and Tian, 2020; Yu et al., 2020).

A major focus of recent studies has been efforts to explain how pollution issues and environmental problems are addressed from the perspective of career incentives (Cao, Kleit, and Liu, 2016), that is, the pollution-promotion question (Wu and Cao, 2021). There has been extensive evidence of pollution for economic development and political promotion incentive (Jia, 2017; Wu and Chen, 2016; Cao et al., 2016; Pu and Fu, 2018; Wu and Cao, 2021). Since the fiscal decentralization of the 1990s, local politicians have been granted strong power as agents of the central government (Zhang and Zou, 1998) to prioritize the local economy and deliver high economic growth targets in exchange for promotion, even at extremely high environmental cost (Maskin et al., 1997; Li and Zhou, 2005; Zheng et al., 2014; Yu et al., 2020; Wu and Cao, 2021). Jia (2017) finds that government officials seek to maximize the possibility of their promotion at the expense of the environment by investing more in high-pollution enterprises to promote economic growth, known as "pollute for promotion". Feng et al. (2018) find that environmental performance did not significantly impact political turnover of municipal party secretaries during the period 2002-2013. A few studies have looked at local pollution abatement performance after the central government began including environmental performance into the promotion criteria (State Council, 2006; Pu and Fu, 2018). Zheng et al. (2014), finding that better performance on air pollution treatment spending and air pollution control is associated with a higher chance of city mayor promotion. Pu and Fu (2018) show that pollution decreases the chances of promotion for city mayors, affirming that better pollution treatment has a positive effect on promotion. Wang and Lei (2020) also find that efforts toward environmental protection have a positive return on the careers of local officials. Wu and Cao (2021) find that local officials who are better at reducing air pollution are more likely to be promoted at the county level, although they do not find a pollution–promotion link at the prefectural or provincial levels.

Another focus of studies on the political economy of pollution is on providing a better understanding of the relationship between political connections, corruption, and relevant pollution outcomes (Candau and Dienesch, 2017). On one hand, it has been widely accepted that political connections are highly relevant to private returns and corruption (Fisman et al., 2014; Lehne, Shapiro, and Eynde, 2018). A growing number of papers have documented how political connections bring benefits to firms, households, and individuals (Amore and Bennedsen, 2013; Lehne, Shapiro, and Eynde, 2018). On the other hand, it has been documented that political corruption can increase pollution intensity (Lopez and Mitra, 2000), decrease ecological efficiency (Wang et al., 2020), and harm the environment (Lopez and Mitra, 2000; Fredriksson, List and Millimet, 2003; Biswas et al., 2012; Candau and Dienesch, 2017). Corruption can affect pollution through political protection realized through bribing or lobbying government officials (Fredriksson and Neumayer, 2014) or by obtaining lax environmental regulations (Shleifer and Vishny, 1993; Biswas et al., 2012; Cao et al., 2019; Hong and Teh, 2019), which all increase local pollution levels and contribute to the so-called pollution haven effect (Copeland and Taylor, 1994; Dean, Lovely, and Wang, 2009). Chen et al. (2018) find that corruption behavior can weaken environmental regulations and exacerbate pollution. Zhou, Wang, and Chen (2020) use the anti-corruption campaign in China begun in 2013 as an exogenous shock, finding that the anti-corruption campaign has reduced air pollution in China by 20.3% through the more stringent environmental regulations that were subsequently introduced.

2.2 Patronage Connections between Politicians

Patronage connections, that is, the hierarchical ties of reciprocal benefits between politicians, have long been an essential yet informal part of political systems (Scott, 1972). In a patronage connection, higher-level officials or

patrons provide personal endorsement for promotions or protection, and lower-level officials or clients respond to the demands and interests of their patrons (Jiang, 2018). Patronage connections function as an informal institution regulating interactions among political elites. Many studies have emphasized the favoritism channel of patronage connections (Fisman, 2014; Shih, 2004; Khwaja and Mian 2005; Opper and Brehm 2007; Shih, Adoplh, and Liu, 2012) or discussed its negative influence on government ability (Geddes, 1994; Rose-Ackerman, 1999; Stokes, 2005).

The Chinese bureaucracy is characterized by a personalized authority that highlights the importance of personal relationships (Pye, 1995). It has been widely recognized that political patronage connections are essential in the Chinese political context, which has been shown by both anecdotal evidence and systematic empirical analysis (Shih, Adolph, and Liu, 2012; Jia, Kudamatsu, and Seim, 2015). Within the Chinese context, local officials are appointed by upper-level officials (He, 2015) who play a major role in personnel control within the area under their governance (Maskin et al., 1997; Yu, Cai, and Gao, 2016). Within the Chinese context, previous studies have emphasized the importance of patronage connections in the appointment, promotion and rotation (Opper, Nee, and Brehm, 2015; Wu and Chen, 2016), resource allocations (Shih, 2004, 2008; Yu, Yao, Zheng, and Zhang, 2020), and alignment of interests and targets of different levels of government (Jiang, 2018).

3. Data and Method

3.1Data

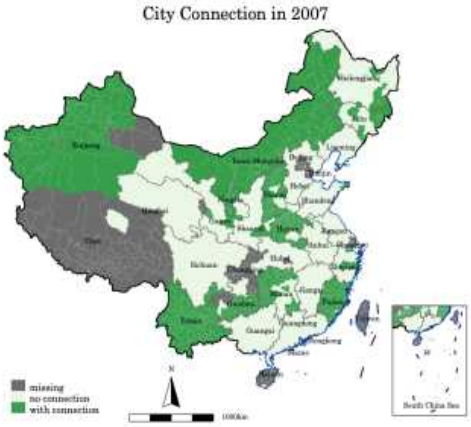
This study employs a uniquely detailed data set comprising Chinese enterprise pollution and political elites patronage data at the firm, city, and year levels from 1998 to 2012. The analysis is conducted based on data from three sources: the firm-level Chinese Industrial Enterprise Dataset (CIED), covering 1998 to 2012; the Chinese Industrial Enterprise Pollution Dataset (CIEPD), covering 1998 to 2012; and the Chinese Political Elite Database (CPED), covering late 1990s to 2015.

The CIED covers all enterprises with annual sales greater than 5 million RMB from 1998 to 2012, including both state-owned enterprises (SOEs) and non-SOEs. Each firm is identified by a 10-digit code, in which the first 4 digits represent the firm location, namely, the province and prefecture where it is located. The data set comprises annual survey data on enterprises' basic information, production status, and financial information drawn from the balance sheets, profit and loss statements, and cash flow statements. Specifically, it includes variables for firm location, industrial activities and sectors, gross output, value added, sales, and total labor input.

The CIEPD provides survey-based information on pollution, emissions, and the environmental management of Chinese industrial enterprises from 1998 to 2012. This data set includes information on enterprises' basic information, indicators on its air, water, and solid waste generation, reduction and emissions, and adoption of pollution control measures. It provides disaggregated data for the study of environmental governance and industrial pollution in China. In this study, pollution intensity is measured by the emissions of pollutant per unit of output.

The CPED has provided biographical data of over 4000 Chinese municipal, provincial, and national leaders in China since the late 1990s, including detailed information on their education history and career path (Jiang, 2018). The CPED data set was used to construct a city–year-level panel data set, focusing on whether the city secretary or the mayor is connected to higher-level leaders, namely, province secretaries in this study. The CPED data set deduces patron–client relations from past promotions and provides an accurate measure of political patronage connections.

This study first matches the CIED with the CIEPD using both the enterprise identifier and the name of firms following the method developed by Brandt, Biesebroeck, and Zhang (2014) and Feenstra, Li, and Yu (2014). We then match each enterprise with relevant city political elites using the city administration code and the survey year. Next, we can use panel data with firm–city–year data for individuals using 290,170 observations from 1999 to 2012 (when SO2 is used as the independent variable), each including a city secretary and a mayor. This dataset is highly representative of China as it covers as much as 50% of China's SO2 emissions and 50% of total output in all of China's industrial enterprises. The summary statistics of the main variables used in this study are reported in Table 1. Figure 1 provides the county-level geography distribution of SO2 pollution and political connections in 2007, which is one of the years with the most severe SO2 pollution.



(a)

(b)

Figure 1: SO2 Pollution and Political Connections in 2007

Table 1: Summary Statistics

	Domestic			Hong Kong, Macau, Taiwan			Foreign		
	Mean	SD	N	mean	sd	N	Mean	SD	N
Panel A: Pollution Data									
lnSO2	1.99	2.14	242859	0.87	2.46	24581	0.24	2.77	22730
lnCOD	0.58	2.55	158740	0.16	2.32	18932	-0.33	2.32	17390
ln Ammonia Nitrogen	-2.00	2.68	68586	-2.52	2.45	11099	-3.07	2.53	9939
lnGas	0.00	2.12	227207	-0.89	2.10	21972	-1.14	2.15	20145
lnDust	1.29	2.26	195271	-0.05	2.45	17805	-0.32	2.60	16196
Panel B: Firm Production Data									
lnOutput	7.98	1.62	242859	8.64	1.66	24581	9.09	1.76	22730
lnEmployee	5.50	1.18	242859	5.73	1.11	24581	5.80	1.15	22730
open	15.06	14.69	242859	9.47	6.22	24581	9.05	6.26	22730
New *open*	0.05	0.22	242859	0.03	0.17	24581	0.03	0.18	22730
Export (%)	0.07	0.20	242859	0.33	0.41	24581	0.32	0.39	22730
Panel C: Political Elites									
mayor	0.47	0.50	242859	0.40	0.49	24581	0.40	0.49	22730
secretary	0.43	0.49	242859	0.37	0.48	24581	0.37	0.48	22730
secretaryormayor	0.55	0.50	242859	0.48	0.50	24581	0.49	0.50	22730

Note: The variable *mayor* refers to the mayor's connection to the provincial party secretary, the variable *secretary* refers to the city party secretary's connection to the provincial party secretary, and the variable *secretaryormayor* refers to the mayor or city party secretary's connection to the provincial party secretary. These three variables take the value 1 if a patronage connection exists, and 0 otherwise.

3.2 Empirical Strategy

This section outlines the empirical strategy. This study compares the intensity of SO2 emissions in the presence and absence of political connections of city party secretaries and mayors to higher-level governors. Firm-level data on SO2 intensity are used as an indicator of pollutant level in baseline regressions for the following considerations. SO2 is an important pollutant in the atmosphere and is colorless and toxic, with an irritating odor. SO2 can easily enter

the human body and pose a threat to human health. In addition to being toxic to humans, SO2 can also interact with water vapor and oxygen in the atmosphere to produce sulfuric acid, which can turn into acid rain. SO2 can also form aerosol particles in complex ways and has been found to be a major contributors to PM2.5 and haze problems in China. China used to be the world's largest SO2 emitter. SO2 is one of the most harmful pollutants associated with China's rapid growth of the early 2000s. This study also uses as other indicators a range of metrics and pollutants, including chemical oxygen demand (COD), ammonia nitrogen, waste gas, and industrial dust, in following robustness analysis.

The baseline specification is as follows:

$$\ln P_{ijkt} = \alpha + \beta C_{jt} + \lambda X_{ijkt} + \mu_j + \nu_k + \varphi_t + \varepsilon_{ijkt}$$

where lnP_{ijt}, the dependent variable, indicates the logarithm of the pollutant intensity, which is measured by the amount of SO2 emissions per unit of total output of firm i in city j, industry k and year t. The main explanary variable C_{jt} indicates whether or not the municipal secretary or the mayor of city j in year t is connected to the provincial secretary, which is a dummy variable taking a value of 1 if a patronage connection is found and 0 otherwise. In specific, C_{jt} includes $mayor$, $secretary$, and $secretaryormayor$. X_{ijt} is a series of control variables, including the logarithm of the total outputs of the enterprise, the share of intermediate inputs in total outputs, the logarithm of total employees, years of operation, the share of exported sales in total sales. The baseline regression also controls for fixed effects, where μ_j is the city fixed effect controlling for all time-invariant differences between cities, ν_k is the industry fixed effect controlling for all time-invariant differences between industries, and φ_t is the year fixed effect controlling for time-variant changes that affect all cities and industries simultaneously. ε_{ijkt} represents the standard error term.

4. Empirical Results

This section presents the main results. First, we measure the impact of a city secretary or mayor having political connections to higher levels on enterprises' pollution intensity in the relevant cities. We then identify the causal relationship between enterprise pollution and political connections using the interaction with political connection and newly built firms. Third, we conduct robustness tests using a range of metrics and pollutants, including COD, ammonia nitrogen, waste gas, and industrial dust. Finally, heterogeneity tests are conducted for different ownership subsamples and different enterprise sizes.

4.1Baseline Analysis

We first conduct a baseline analysis to investigate whether political elites with connections to higher-level leaders would allow for more pollutant enterprises in cities under their governance. Table 2 presents the baseline results on the effect of political connections on enterprise SO2 intensity. Regressions include city, industry, and year fixed effects in columns 1, 2, and 3 of Table 2, and city, industry–year, and year fixed effects in columns 4, 5, and 6.

The results show a positive effect of presence of a political connection on the SO2 intensity in relevant cities. Columns 1 and 4 show that if the city mayor is connected to the provincial governor, the SO2 intensity could increase by 1.97% or 2.35% depending on the set of fixed effects. Columns 2 and 5 show that if the city secretary is connected to the provincial governor, the SO2 intensity could increase by 1.69% or 1.77%. Columns 3 and 6 show that if either the city mayor or the secretary is connected to the provincial governor, the SO2 intensity could increase by 2.53% or 2.88%. Table 2 also shows that larger enterprises with greater output tend to be cleaner in terms of SO2 intensity. With a 1% increase in the gross output of the enterprise, SO2 intensity will decrease by about 0.6%. However, enterprises with more employees tend to pollute more, which implies that pollutive industries are usually labor intensive as well, for instance the coal and mining industry, metal industry, and cement production industry. Enterprises that have been operating for longer also tend to pollute more. With an additional year after opening, SO2 intensity increases by about 0.2%. There are many possible reasons for this, examples being older firms often belong to manufacturing industries that are generally more polluting, and they may rely on out-of-date technology and equipment. One interesting finding is that exporting firms have not been found to pollute more, which might speak to the studies on the pollution haven effect, notwithstanding that this is not a causal identification.

Table 2: SO2 Intensity and Political Connections

	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2
	(1)	(2)	(3)	(4)	(5)	(6)
mayor	0.0197***			0.0235***		
	(0.0071)			(0.0071)		
secretary		0.0169**			0.0177**	
		(0.0072)			(0.0073)	
secretaryormayor			0.0253***			0.0288***
			(0.0071)			(0.0072)
InOutput	-0.6243***	-0.6243***	-0.6431***	-0.6213***	-0.6213***	-0.6395***
	(0.0031)	(0.0031)	(0.0030)	(0.0031)	(0.0031)	(0.0030)
InEmployee	0.3516***	0.3516***	0.3661***	0.3496***	0.3496***	0.3635***
	(0.0045)	(0.0045)	(0.0043)	(0.0045)	(0.0045)	(0.0043)
open	0.0018***	0.0018***	0.0024***	0.0016***	0.0017***	0.0021***
	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0002)
export	-0.7283***	-0.7282***	-0.7067***	-0.7076***	-0.7076***	-0.6815***
	(0.0141)	(0.0141)	(0.0134)	(0.0141)	(0.0141)	(0.0134)
cons	4.1116***	4.1107***	3.0182***	4.4522***	4.4510***	3.3863***
	(0.0493)	(0.0493)	(0.0488)	(0.0928)	(0.0928)	(0.0990)
City	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes			
Year	Yes	Yes	Yes			
Industry x Year				Yes	Yes	Yes
N	291394	291394	332286	291394	291394	332286
adj.R2	0.471	0.471	0.475	0.475	0.475	0.479

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. Regressions include city, industry, and year fixed effects in columns 1, 2, and 3, and city, industry–year, and year fixed effects in columns 4, 5, and 6.

4.2 Causal Relationship Identification

To deal with the potential endogeneity of political connections, this study attempts to identify the causal relationship between pollution behavior and political connections. The endogeneity of political connections could be because of several reasons. First, politically connected city secretaries and mayors might receive more resources or policy favors (Jia, 2017; Jiang, 2018) and be assigned to more productive cities with more long-established polluting enterprises. Second, highly polluting firms might seek government protection, in terms of building political connections for their city secretaries and mayors, or influence the appointment of local officials. That is, there can be a reverse causality from intensive pollution to patronage connections of political elites.

To identify the causal relationship, this study first employs a quasi-DID approach using interactions between a dummy for political connection and a dummy for newly opened enterprises to identify whether enterprises newly opened when the city secretary or city mayor is connected to higher-level political governors are more pollutive than those newly opened when there are no such connections. Newly opened enterprises are defined as firms starting operation in each survey year. For instance, for survey wave 2003, enterprises starting operations during 2003 are defined as newly opened. IT should be noted that this could underestimate the number of new firms, since firms that opened in late 2002 have also been in operation for less than one year. However, information about the month when the survey is conducted was unavailable.

Table 3 presents statistical evidence for the causal effect between political connections and higher enterprise SO2 intensity. The coefficients for the city mayor's connections, city secretary's connections, and both city mayor or secretary's connections are still positive and significant. Personal connections of the city mayor, city secretary, or either of them to higher-level governors increases the enterprise SO2 intensity by 2.27%, 1.70%, and 2.77%, respectively, as shown in columns 4, 5, and 6 of Table 3. The coefficient for the dummy of newly-started firms is positive but not significant, showing that the SO2 intensity is balanced between newly started firms and previously established firms. The main focus of this study is the interaction term between the political connection and the newly started dummy. The positive coefficients show that enterprises that are newly started when there are higher-level

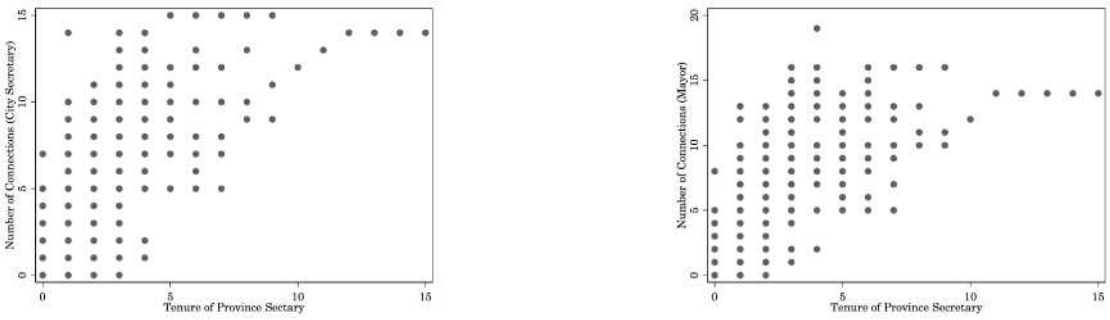
political connections are more SO2-intensive than those that are not. The results in columns 3 and 6 show that when the either the city mayor or the city secretary is connected to the provincial governor, the SO2 intensity of newly started firms in the city could be 11.75% more intensive than firms that are newly started when there are no such connections. It is worth noting that the results in Table 3 do not rule out the possibility that political elites with connections might be assigned to more productive, resourceful, and polluting cities. In actuality, the results in Table 3 show that previously established enterprises are still more polluting in cities with personal connections of political elites than those without. This suggests that political elites are indeed assigned to more pollutive regions. Table 3 also provides causal evidence for another reason behind the high pollution in some cities, namely, that city mayors and secretaries with political connections allow more polluting firms to begin operations during their terms. The findings show that political connections increase pollution even after controlling for the start time of the firms.

Table 3: Causal Relationship Identification by Quasi-DID

	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2
	(1)	(2)	(3)	(4)	(5)	(6)
mayor	0.0192***			0.0227***		
	(0.0071)			(0.0071)		
secretary		0.0163**			0.0170**	
		(0.0073)			(0.0073)	
secretaryormayor			0.0245***			0.0277***
			(0.0071)			(0.0072)
new	0.0354	0.0553	0.0060	0.0322	0.0537	0.0068
	(0.0401)	(0.0364)	(0.0388)	(0.0401)	(0.0363)	(0.0387)
mayor x *new*	0.0762			0.0821		
	(0.0547)			(0.0545)		
secretary x *new*		0.0434			0.0464	
		(0.0550)			(0.0548)	
secretaryormayor x *new*			0.1175**			0.1211**
			(0.0524)			(0.0522)
InOutput	-0.6253***	-0.6253***	-0.6448***	-0.6222***	-0.6222***	-0.6410***
	(0.0031)	(0.0031)	(0.0030)	(0.0031)	(0.0031)	(0.0030)
InEmployee	0.3593***	0.3594***	0.3767***	0.3565***	0.3566***	0.3730***
	(0.0044)	(0.0044)	(0.0042)	(0.0044)	(0.0044)	(0.0042)
Export	-0.7332***	-0.7332***	-0.7151***	-0.7117***	-0.7117***	-0.6885***
	(0.0141)	(0.0141)	(0.0134)	(0.0141)	(0.0141)	(0.0134)
cons	4.1248***	4.1237***	3.0516***	4.4598***	4.4583***	3.4006***
	(0.0492)	(0.0492)	(0.0488)	(0.0925)	(0.0925)	(0.0976)
City	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes			
Year	Yes	Yes	Yes			
Industry x Year				Yes	Yes	Yes
N	292110	292110	333309	292110	292110	333309
adj.R2	0.471	0.471	0.475	0.475	0.475	0.480

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. Regressions include city, industry, and year fixed effects in columns 1, 2, and 3, and city, industry–year, and year fixed effects in columns 4, 5, and 6.

For causality identification, this study also uses an IV approach to address the endogeneity of political connections. We use the tenure of the current provincial secretary as an instrument variable for political connections. For instance, if the provincial secretary took office in 2004, the number of years since their appointment as of the year 2006 would be 2. When a new provincial secretary is appointed, only a few city officials are able to establish connections. As provincial secretaries promote new city officials and cultivate their own networks later on, the number of patron–client connections grows steadily throughout their tenure (Jiang, 2018). As the period since a provincial secretary's appointment increases, it becomes more likely that city level officials will be connected to them. In China, there is frequent turnover of cadres at the provincial level (Huang, 2002; Jiang, 2018). In addition to promotion and termination leading to new provincial secretaries, the rotation of officials among equally ranked positions serves as another important method of turnover (Wu and Chen, 2016). Figure 2 shows that the number of connections between city secretaries or mayors and the provincial secretary increases along with the provincial secretary's tenure.



(a) (b)

Figure 2: Number of Political Connections and the Tenure of Provincial Party Secretary

In the following regression, this study uses the number of years since the current provincial secretary's appointment as an instrument variable for the 2SLS estimation, with the results presented in Table 4. The first-stage F-statistic for the IV satisfies the rule of thumb (which is more than 10), indicating that there is no weak IV problem. The IV estimates show that having patronage connections results in a significant increase of 2.92%, 3.26%, and 2.88% in SO2 intensity for personal connections of the mayor, city secretary, or either. The IV estimates in Table 4 are slighter larger the ordinary least squares estimates. It should be noted that it is possible that the IV approach is helpful in addressing the endogeneity problem and presents a more accurate estimate of the effect of political connections on pollution. In addition, it is worth noting that the IV estimations represent the local average treatment effects of an instrument-induced shift in patronage connections (Brinch et al., 2017).

Table 4: Causal Relationship Identification by IV Approach

	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2
	(1)	(2)	(3)	(4)	(5)	(6)
mayor	0.0292**			0.0292**		
	(0.0136)			(0.0136)		
secretary		0.0237			0.0326**	
		(0.0149)			(0.0152)	
secretaryormayor			0.0210			0.0288**
			(0.0132)			(0.0134)
InOutput	-0.6213***	-0.6243***	-0.6243***	-0.6213***	-0.6213***	-0.6213***
	(0.0031)	(0.0031)	(0.0031)	(0.0031)	(0.0031)	(0.0031)
InEmployee	0.3496***	0.3516***	0.3516***	0.3496***	0.3496***	0.3496***
	(0.0045)	(0.0045)	(0.0045)	(0.0045)	(0.0045)	(0.0045)
open	0.0016***	0.0018***	0.0018***	0.0016***	0.0017***	0.0017***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Export	-0.7076***	-0.7281***	-0.7282***	-0.7076***	-0.7074***	-0.7075***
	(0.0141)	(0.0141)	(0.0141)	(0.0141)	(0.0141)	(0.0141)
cons	4.4523***	4.1101***	4.1104***	4.4523***	4.4503***	4.4516***
	(0.0927)	(0.0493)	(0.0493)	(0.0927)	(0.0927)	(0.0927)
City	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes			
Year	Yes	Yes	Yes			
Industry x Year				Yes	Yes	Yes
F ristStageF statistic						
N	291394	291394	291394	291394	291394	291394
adj.R2	0.475	0.471	0.471	0.475	0.475	0.475

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. Regressions include city, industry, and year fixed effects in columns 1, 2, and 3, and city, industry–year, and year fixed effects in columns 4, 5, and 6.

4.3 Robustness Checks

To verify the reliability of these findings, this study also conducts empirical research on other pollutants. Table 5 presents the results of robustness checks. The explanatory variables include the intensity of COD, ammonia nitrogen, waste gas, and industrial dust, shown in in columns 1 to 4, respectively. The main explanatory variable used in Table 5 is whether either the city mayor or city secretary has political connections to the provincial governor. The same set of control variables as in Table 5 is included in the robustness checks, and city, year, industry–year fixed effects are included. When either the city mayor or the city secretary is connected to the provincial governor, the COD, ammonia nitrogen, waste gas, and industrial dust (which is the largest among all pollutants) intensities increase by 2.06%, 3.24%, 2.20%, and 6.26%, respectively. Table 5 shows that the presence of political connections of the city mayor or secretary increase the pollution intensity for other kinds of pollutants as well.

This study uses the presence of personal connections between provincial secretaries and city leaders as the main explanatory variable, while the connections between provincial governors and city leaders could also be important. As a robustness test, the results for connections between city secretaries or mayors and provincial governors are also provided in the appendix as Table A1, which are in line with the above findings. This study also considers the effects of city mayors or secretaries having the same university and hometown as provincial secretaries. The results are provided in the appendix as Table A2.

Table 5: Other Pollutant Intensity and Political Connections

	COD	Ammonia Nitrogen	Gas	Dust
	(1)	(2)	(3)	(4)
secretaryormayor	0.0206**	0.0324**	0.0220***	0.0626***
	(0.0092)	(0.0155)	(0.0069)	(0.0085)
InOutput	-0.6489***	-0.6895***	-0.5107***	-0.7270***
	(0.0033)	(0.0049)	(0.0029)	(0.0033)
InEmployee	0.4668***	0.4653***	0.3925***	0.3633***
	(0.0048)	(0.0071)	(0.0041)	(0.0048)
open	0.0043***	0.0066***	-0.0014***	0.0006**
	(0.0003)	(0.0005)	(0.0002)	(0.0003)
Export	-0.1393***	-0.2067***	-0.5255***	-0.6114***
	(0.0126)	(0.0184)	(0.0128)	(0.0151)
cons	1.8331***	-2.1899***	0.7770***	4.1619***
	(0.1697)	(0.3466)	(0.0864)	(0.1021)
City	Yes	Yes	Yes	Yes
Industry xYear	Yes	Yes	Yes	Yes
Y ear	Yes	Yes	Yes	Yes
N	308517	142027	334164	270352
adj.R2	0.397	0.397	0.476	0.479

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include city, industry–year, and year fixed effects.

4.4 Heterogeneity

Our study next explores whether the effect of the personal connections of political elites on pollution intensity is heterogeneous among different enterprises. Two main aspects are considered: the type of ownership and the size of the firm.

First, this study tests the heterogeneous effect among firms with different types of ownership. The type of ownership is important, especially in China. One reason is that SOEs can be considered as extended arms of the government (Yu et al., 2020), and their pollution behavior has a close relationship with political connections. Another reason is that ownership determines resource allocation inside firms (Jensen and Meckling, 1976), which is highly relevant to pollutant intensity. Considering the reality of China, the full sample is divided into three subsamples: domestically owned firms, firms owned by Hong Kong, Macao, or Taiwan, and foreign-owned firms. Table 6 presents the estimated results for each of these subsamples. Columns 1 to 3 show that political connections still increase enterprises' SO2 intensity significantly among domestically owned firms. The presence of a personal connection of

the city mayor, city secretary, or either with a higher-level leader increases the SO2 intensity by 2.55%, 1.95%, and 3.40%, respectively. Columns 4 to 6 present the results for firms owned by Hong Kong, Macao, or Taiwan capitals; these changes are not significant, except when there is a political connection of the city mayor. Columns 7 to 8 present the results for foreign-owned firms, showing that there is no significant impact of political connections on enterprise SO2 intensity among foreign-owned firms. By comparing domestically owned firms and foreign-owned firms, we see that political connections of the city mayor or secretary significantly increase pollution intensity through their impact on domestic firms.

Table 6: SO2 Intensity and Political Connections: by Type of Ownership

	Domestic			Hong Kong, Macao, Taiwan			Foreign		
	lnS02	lnS02	lnS02	lnS02	lnS02	lnS02	lnS02	lnS02	lnS02
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
mayor	0.0255***			0.0757***			-0.0126		
	(0.0075)			(0.0280)			(0.0307)		
secretary		0.0195**			-0.0263			0.0091	
		(0.0077)			(0.0281)			(0.0324)	
secretaryormayor			0.0340***			0.0399			-0.0323
			(0.0076)			(0.0275)			(0.0305)
InOutput	-0.5958***	-0.5958***	-0.6049***	-0.5944***	-0.5951***	-0.6114***	-0.7133***	-0.7133***	-0.7443***
	(0.0034)	(0.0034)	(0.0033)	(0.0112)	(0.0112)	(0.0106)	(0.0114)	(0.0114)	(0.0106)
InEmployee	0.3648***	0.3648***	0.3723***	0.1932***	0.1941***	0.2234***	0.3413***	0.3414***	0.3742***
	(0.0049)	(0.0049)	(0.0047)	(0.0158)	(0.0158)	(0.0151)	(0.0171)	(0.0171)	(0.0161)
open	-0.0007***	-0.0007***	-0.0007***	0.0042**	0.0041**	0.0068***	0.0083***	0.0083***	0.0069***
	(0.0003)	(0.0003)	(0.0002)	(0.0019)	(0.0019)	(0.0017)	(0.0021)	(0.0021)	(0.0020)
Export	-0.5129***	-0.5129***	-0.4699***	-0.7021***	-0.7022***	-0.6713***	-0.5535***	-0.5535***	-0.4990***
	(0.0178)	(0.0178)	(0.0168)	(0.0350)	(0.0350)	(0.0333)	(0.0385)	(0.0385)	(0.0357)
cons	4.1818***	4.1805***	3.3026***	5.9122***	5.9345***	4.6159***	4.5096***	4.4825***	3.3440***
	(0.0938)	(0.0938)	(0.0997)	(0.8691)	(0.8832)	(0.8587)	(0.6962)	(0.6951)	(0.6293)
City	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry xYear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Y ear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	242859	242859	275899	24581	24581	27641	22730	22730	27452
adj.R2	0.444	0.444	0.443	0.478	0.478	0.475	0.520	0.520	0.532

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include city, industry–year, and year fixed effects.

Second, this study tests the heterogeneous effect among firms of different scales. Medium-sized or small enterprises have grown rapidly and are the main contributors to China's environmental problems (Meng et al., 2018), and should be given greater attention in pollution mitigation efforts. In addition, large manufacturing firms often pollute heavily and more likely to have close ties to political elites. Table 7 presents the estimated results for the three subsamples. Columns 1 to 3 show that the presence of a political connection of the city mayor, city secretary, or either with higher-level leaders increases the SO2 intensity of large enterprises by 3.85%, 5.90%, and 6.23%, respectively. Columns 4 to 6 show that the presence of a political connection of the city mayor, city secretary, or either increases the SO2 intensity of medium-sized enterprises by 7.75%, 3.05%, and 5.64%, respectively. Columns 7 to 9 show that the presence of a political connection of the city mayor, city secretary, or either increases the SO2 intensity of small enterprises by 3.30%, 1.45%, and 2.58%, respectively. These results provide evidence that political connections increase enterprise SO2 intensity for large, medium, and small firms.

Table 7: SO2 Intensity and Political Connections: by Enterprise Size

	Large			Medium			Small		
	lnSO2 (1)	lnSO2 (2)	lnSO2 (3)	lnSO2 (4)	lnSO2 (5)	lnSO2 (6)	lnSO2 (7)	lnSO2 (8)	lnSO2 (9)
mayor	0.0385			0.0775***			0.0330***		
	(0.0305)			(0.0159)			(0.0088)		
secretary		0.0590*			0.0305*			0.0145	
		(0.0320)			(0.0162)			(0.0089)	
secretaryormayor			0.0623**			0.0564***			0.0258***
			(0.0299)			(0.0160)			(0.0088)
lnOutput	-0.6205***	-0.6203***	-0.6207***	-0.6781***	-0.6782***	-0.7025***	-0.6471***	-0.6470***	-0.6612***
	(0.0152)	(0.0152)	(0.0134)	(0.0072)	(0.0072)	(0.0068)	(0.0040)	(0.0040)	(0.0038)
lnEmployee	0.5659***	0.5661***	0.5705***	0.3912***	0.3914***	0.4092***	0.3102***	0.3102***	0.3207***
	(0.0236)	(0.0236)	(0.0206)	(0.0131)	(0.0131)	(0.0124)	(0.0062)	(0.0062)	(0.0058)
open	0.0027***	0.0027***	0.0047***	0.0014***	0.0014***	0.0022***	-0.0019***	-0.0018***	-0.0020***
	(0.0008)	(0.0008)	(0.0006)	(0.0005)	(0.0005)	(0.0004)	(0.0003)	(0.0003)	(0.0003)
Export	-0.4646***	-0.4648***	-0.4036***	-0.5494***	-0.5488***	-0.5007***	-0.6698***	-0.6694***	-0.6528***
	(0.0696)	(0.0696)	(0.0607)	(0.0310)	(0.0311)	(0.0293)	(0.0177)	(0.0177)	(0.0167)
cons	2.6371***	2.6311***	2.1486***	4.9521***	4.9490***	4.0206***	4.6579***	4.6569***	3.6496***
	(0.3543)	(0.3542)	(0.3802)	(0.1921)	(0.1923)	(0.2190)	(0.1128)	(0.1129)	(0.1151)
City	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry xYear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	17572	17572	22566	61141	61141	70992	172103	172103	195802
adj.R2	0.561	0.561	0.553	0.496	0.496	0.503	0.443	0.443	0.444

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include city, industry–year, and year fixed effects.

This study also tests the heterogeneous effect among different geographical regions and among different sectors, which are provided in appendix B as Table B1 and Table B2.

5. Extension Analysis and Mechanisms

This study conducts a series of extension analyses to investigate the mechanism behind the high pollution intensity related to political connections. First, it checks whether politically connected officials are assigned to more productive regions. It then gives evidence of the "pollution for promotion" mechanism by proving the existence of the political tournament championship (Li and Zhou, 2005). Finally, it analyzes whether corrupt officials are related to higher pollution intensity and investigates how the interaction between political connections and corrupt behavior further increases pollution intensity.

5.1 Favorable Conditions or Test of Ability

As mentioned in the introduction and literature review, a large body of political economy studies have documented how personal connections could bring more resources to clients from their patrons. In China's "relationship-based economy," resources could be biased towards local officials with political connections (Opper and Brehm, 2007). It is possible that connected political elites are related to higher pollution intensity, either because they were designated to cities with favorable conditions as a benefit or because they were appointed to more polluting regions as a test of their abilities (Jia, 2017).

In this section, we first examine this mechanism by analyzing the city economic scale in terms of GDP on the year and 1 and 2 years before the as the appointment of a city secretary or mayor. If this favorable conditions mechanism exists, we would expect that secretaries and mayors with political connections would be appointed to cities with a higher GDP. Table 8 shows the results of this mechanism for both secretaries and mayors. In each column, we include the population size for the same period with the independent variable, the local official's educational background, the city fixed effect to control for city characteristics, and the year fixed effect to control for common growth trends or economic shocks that influence all cities at the same time, such as the global financial crisis of 2008,

the Four-trillion Economic Stimulus Plan enacted at the end of 2008. Columns 1 to 3 present the results for city secretaries, which show that local officials are appointed to cities with better economic performance if they have political connections to the provincial secretary. The city GDP at the starting year and 1 and 2 years before the appointment of secretaries with connections is 7.60%, 7.27%, and 10.05% higher than that of cities whose secretaries have no personal connections. Columns 4 to 6 show similar results for mayors. The city GDP at the starting year and 1 and 2 years before the appointment of mayors with connections is 12.47%, 12.24%, and 14.05% higher than that of cities whose mayors have no personal connections.

Table 8: City GDP before Local Officials Take Office

	Secretary			Mayor		
	Take Office	One Year	Two Years	Take Office	One Year	Two Years
	(1)	(2)	(3)	(4)	(5)	(6)
Inpop	0.3990***	0.3854***	0.8104***	0.1643***	0.3812***	0.8778***
	(0.0494)	(0.0739)	(0.1626)	(0.0364)	(0.0584)	(0.1595)
secretary	0.0760***	0.0727***	0.1005***			
	(0.0093)	(0.0098)	(0.0109)			
education	0.0066	-0.0081	-0.0249**			
	(0.0091)	(0.0098)	(0.0116)			
mayor				0.1247***	0.1224***	0.1405***
				(0.0080)	(0.0080)	(0.0080)
education				0.0125	-0.0007	0.0086
				(0.0083)	(0.0088)	(0.0089)
cons	13.2297***	13.4111***	10.4960***	14.8527***	13.4871***	10.0487***
	(0.3459)	(0.5125)	(1.1055)	(0.2540)	(0.4027)	(1.0916)
City	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	4155	3755	3463	4080	3781	3494
adj.R2	0.955	0.954	0.940	0.932	0.962	0.966

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include city and year fixed effects. The variable *lnpop* refers to the log of the city population at the starting year and 1 and 2 years before the appointment of secretaries (columns 1 to 3) and mayors (columns 4 to 6).

We next further rule out the possibility that local officials are appointed to more polluting regions as a challenge to test their abilities. We compare the pollution intensity of SO2, waste-water, and smoke at the starting year and 1 and 2 years before the appointment of local officials with and without patronage connections. The results for the presence of political connections of the city mayor, secretary, or either, shown in Table 9, indicate that connected officials are assigned to less polluting regions when the city GDP and population have been controlled, notwithstanding that the coefficients are not all significant. Comparing the results shown in Table 8 and those in Table 9, we see that politically connected officials are assigned to more productive regions with more favorable conditions as a benefit rather than more polluting regions as a challenge.

Table 9: City Pollution before Local Officials Take Office

	Secretary			Mayor		
	Take Office	One Year	Two Years	Take Office	One Year	Two Years
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: SO2 Emissions						
Ingdp	0.0471	0.1367***	0.0520	-0.1059**	-0.0309	0.1012**
	(0.0438)	(0.0465)	(0.0523)	(0.0495)	(0.0450)	(0.0507)
Inpop	0.0455	-0.4179*	-0.4826*	0.2416	-0.2298	-0.3768
	(0.2758)	(0.2299)	(0.2855)	(0.1818)	(0.1471)	(0.3104)
connection	-0.0869***	-0.0930***	-0.0476*	-0.0782***	-0.0458**	-0.0730***
	(0.0254)	(0.0250)	(0.0265)	(0.0215)	(0.0191)	(0.0215)
Panel B: Waste Water						
Ingdp	0.0675*	-0.0310	0.0106	-0.0510	-0.0211	0.0486

	(0.0369)	(0.0355)	(0.0431)	(0.0428)	(0.0428)	(0.0422)
Inpop	0.3223*	0.4681***	0.9347***	0.5297***	0.3024***	0.9534***
	(0.1957)	(0.1311)	(0.1887)	(0.1527)	(0.0978)	(0.1915)
connection	-0.0390**	-0.0133	-0.0244	-0.0267	0.0015	-0.0119
	(0.0193)	(0.0199)	(0.0196)	(0.0181)	(0.0188)	(0.0164)
Panel C: Smoke						
Ingdp	0.2121***	0.2315***	0.2041***	0.0800	0.1540***	0.1286**
	(0.0540)	(0.0526)	(0.0640)	(0.0637)	(0.0582)	(0.0610)
Inpop	0.5082*	0.3859	0.7659*	0.8083***	0.7094***	1.3382***
	(0.3079)	(0.2378)	(0.4044)	(0.2831)	(0.1655)	(0.4313)
connection	-0.0299	-0.0618**	-0.0600**	-0.1015***	-0.0727***	-0.0588**
	(0.0295)	(0.0298)	(0.0291)	(0.0285)	(0.0244)	(0.0248)

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include whether local secretaries or mayors concerned have a bachelor degree or higher, as well as city and year fixed effects as control variables. Regressions that control the city GDP per capita instead of the city GDP also show similar results.

5.2Career Incentive

One mechanism behind the high pollution intensity could be so-called “pollute for promotion” incentives (Kahn, Li and Zhao, 2015; Jia, 2017). The promotion system in China is designed to evaluate and promote the city mayors and secretaries who have performed better in fulfilling the targets of the central government. The targets are usually economic growth (Li and Zhou, 2005), revenue collection (Shih, Adolph, and Liu, 2012), or, since the 11th Five Year Plan from 2006, environmental performance (State, 2006). In this context, targets of city mayors and secretaries should be in line with those of upper-level governments.

Until the 11th Five Year Plan (2006-2010), neither China’s central government nor local officials prioritized environmental protection (Zheng et al., 2014), and it was a common to seek economic growth at the cost of the local environment (Yu et al., 2020). The mitigation target of reducing SO2 emissions by 10% was not met during the 10th Five Year Plan (2001-2005), but was exceeded during the 11th Five Year Plan. Before 2006, politically connected city mayors and secretaries were more likely to allow polluting enterprises to create jobs and promote economic growth in order to stand out in the political tournament championship (Li and Zhou, 2005; Jia, 2017). However, with the 11th Five Year Plan in 2006, the State Council proposed making environmental protection part of the evaluation of local governors and regarded it as an assessment criteria for governors selection, appointment, rewards, and punishments (State Council, 2006; Pu and Fu, 2018). Since then, environmental performance has become an important aspect in central government evaluations of local officials. Since 2006, city mayors and secretaries have taken environmental performance into consideration in order to avoid punishment and gain rewards (Pu and Fu, 2018).

This study examines this promotion incentive mechanism by designing an empirical strategy similar to the DID method. The treatment group includes enterprises in cities with a city mayor or secretary connected to provincial governors, while the control group includes those without. The treatment time is defined as the year 2006, since this was the year that environmental performance was included as an important criterion in the promotion of local officials. The treatment time dummy after 2006 takes 1 after year 2006 (including the year 2006), and 0 otherwise. Interactions between the political connection dummy and the treatment time dummy are used to determine the difference before and after the change of promotion criterion in the tournament championship. Table 10 presents the results, in which columns 1 to 3 provide the basic estimations and columns 4 to 6 further control for firm sizes. The coefficients for political connection are significant and positive, which indicates that political connections increase SO2 intensity on average. The coefficients of after 2006 are negative, ranging from −1.637 to −0.997. This indicates that the SO2 intensity has fallen by 63.1% to 80.5% after 2006, when environmental protection and pollution control became an important aspect in the tournament championship. The estimated coefficients of the DID estimator are significantly negative. Columns 1, 2, and 3 show that enterprises in cities with politically connected mayors or secretaries have reduced their SO2 intensity more than those without, by 4.57%, 4.80%, and 3.03%, respectively. The negative DID estimators reflect how city mayors and secretaries have transferred their efforts from being focused solely on economic growth to also include environmental performance after the change of promotion criterion.

The results show that both the intensive SO2 pollution and its rapid abatement since the 11th Five Year Plan can be explained by the career incentive. Pollution intensity has largely changed after the change of promotion criterion. Although previous studies have found solid evidence of pollution for economic growth, this study shows that the career incentive is greater than pollution for promotion. By using a large sample of recent data prior to 2012, which include enough observations after the change of promotion criterion, this study reveals that local officials accommodate their environmental regulations and performance to "stand in the boss's shoes" (Maskin et al., 1997). This section also shows that connected local officials are more likely to conform to the latest promotion criterion. The results reiterate the findings of previous studies, which found that informal institutions could work as an effective tool to align the targets of central and local governments, rather than always functioning as impediments to the formal institutions (Jiang, 2018).

Table 10: SO2 Intensity, Political connection and the Change of Promotion Criterion

	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2
	(1)	(2)	(3)	(4)	(5)	(6)
mayor	0.0547***			0.0596***		
	(0.0098)			(0.0092)		
secretary		0.0621***			0.0510***	
		(0.0098)			(0.0092)	
secretaryormayor			0.0252**			0.0285***
			(0.0099)			(0.0092)
after2006	-1.3652***	-1.3653***	-1.6374***	-0.9972***	-1.0022***	-1.2666***
	(0.0971)	(0.0971)	(0.0989)	(0.0947)	(0.0946)	(0.0993)
mayor xafter2006	-0.0457***			-0.0606***		
	(0.0130)			(0.0120)		
secretary xafter2006		-0.0480***			-0.0567***	
		(0.0131)			(0.0121)	
mayorорsecretary xafter2006			0.0303**			0.0086
			(0.0129)			(0.0118)
InOutput				-0.4781***	-0.4780***	-0.4887***
				(0.0021)	(0.0021)	(0.0020)
cons	2.2425***	2.2431***	0.9628***	5.9051***	5.9075***	4.7683***
	(0.0918)	(0.0918)	(0.0960)	(0.0925)	(0.0924)	(0.0986)
City	Yes	Yes	Yes	Yes	Yes	Yes
Industry xYear	Yes	Yes	Yes	Yes	Yes	Yes
N	392899	392899	439327	392899	392899	439327
adj.R	0.337	0.337	0.345	0.442	0.442	0.449

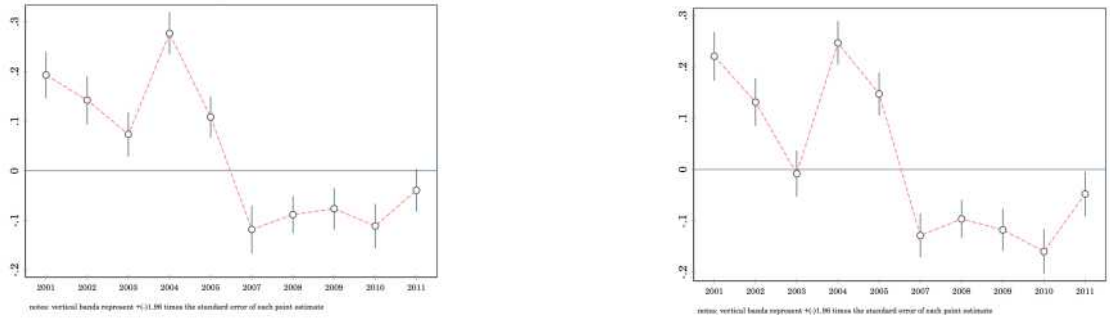
Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include city and industry–year fixed effects.

To examine the effects of patronage connections for each year, we included interaction terms between the patronage connection dummy and dummies for each year, in which 2006 is not included as a benchmark. Observations from 2001 to 2011 are selected to include samples from 5 years before until 5 years after the changes to promotion criteria in 2006. In this regression, we also include the city trend and industry trend fixed effects and year fixed effects. The regression model used is as follows:

$$\ln P_{ijkt} = \alpha + \sum_{r=-5}^{5} \beta_r C_{jt}^{r} + \lambda X_{ijkt} + \mu_{jt} + \nu_{kt} + \varphi_t + \varepsilon_{ijkt}$$

Here, C_{jt}^{r} is the interaction of the year dummy and the connection dummy. The value of C_{jt}^{r} is 1 for observations with connections when considering the r-th year before the change of promotion criterion (if $r < 0$) or the r-th year after the change of promotion criterion (if $r > 0$), and 0 otherwise. In this study, connections of both mayors and city secretary are considered, and the results are shown in Figures 3. Figure 3(a) shows the effect of personal connections of city secretary and Figure 3(b) shows that of personal connections of mayor. The results show that before 2006, when environmental protection began to be considered critical in the promotion of political officials, patronage connections tend to further increase pollution intensity, while after 2006, patronage connections tended to reduce

pollution intensity compared with the benchmark year of 2006. The results shown in section 4 show that while political connections do increase SO2 intensity on average, this is only part of the story. Figure 3 further reveals that patronage connections largely increase SO2 intensity when economic growth was the sole target of upper-level officials and the most important criteria in their promotion, while connections contribute to the mitigation of SO2 when environmental protection was considered as a promotion criteria.



(a) (b)

Figure 3: Coefficients of Political Connections in Each Year

5.3Corruptive Pollution

Another possible mechanism of high SO2 intensity is pollution resulting from corruption (Zhou, Wang and Chen, 2020). As many prior studies have pointed out, politically connected local officials are more likely to become corrupt since they not only have better access to resources but also are less likely to be punished even if they are exposed due to patronage protections. In Table 11, corrupt behavior is used as the main explanatory variable, which takes the value 1 if officials have been found to conduct any corrupt behavior during their political career and 0 otherwise. Columns 1 to 3 use the corrupt behavior of local officials as the main explanatory variable, and the results show that enterprises in cities with corrupt mayors or secretaries have higher SO2 intensity than those without. Columns 4 to 6 include political connections of officials and the interaction terms between political connections and corrupt behavior. Corrupt behavior by city mayors significantly increases enterprise SO2 levels. Meanwhile the interaction term for corrupt behavior of city secretaries is not significant. There is a positive correlation with political connections, as shown in columns 4 to 6 of Table 11, which agrees with the results shown in Table 2. The interaction term of corrupt behavior by mayors and political connections, shown in column 4, is not significant, while corrupt behavior by secretaries, shown in column 5, significantly increases enterprise SO2 intensity by 5.32%. The results in column 6 also show that if either the city mayor or the secretary is corrupt and connected, enterprises in the city would also have higher SO2 intensity. These results show that corruption or political connections of local officials are both related to higher firm SO2 intensity, and that SO2 intensity will further increase if local officials are both connected and corrupt. This indicates that corrupt political elites with patronage connections would allow more pollution since their patronage protections shield them and their career from repercussions (Jia, 2017).

Table 11: SO2 Intensity and the Corrupted Political Elites

	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2
	(1)	(2)	(3)	(4)	(5)	(6)
mayorcrime	0.0451***			0.0485***		
	(0.0129)			(0.0173)		
secretarycrime		0.0059			-0.0124	
		(0.0119)			(0.0148)	
secretaryormayorcrime			0.0279***			-0.0007
			(0.0099)			(0.0134)
mayor				0.0207***		
				(0.0077)		
secretary					0.0098	
					(0.0078)	
secretaryormayor						0.0178**
						(0.0079)

mayorcrime x mayor				-0.0075		
				(0.0227)		
secretarycrime x secretary					0.0532**	
					(0.0218)	
secretaryormayorcrime x *secretaryormayor*						0.0589***
						(0.0167)
InOutput	0.6209***	-0.6218***	-0.6395***	-0.6209***	-0.6218***	-0.6395***
	(0.0032)	(0.0032)	(0.0030)	(0.0032)	(0.0032)	(0.0030)
InEmployee	0.3483***	0.3475***	0.3634***	0.3482***	0.3475***	0.3634***
	(0.0046)	(0.0045)	(0.0043)	(0.0046)	(0.0045)	(0.0043)
open	0.0016***	0.0016***	0.0021***	0.0016***	0.0016***	0.0021***
	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0002)
Export	0.7037***	-0.7094***	-0.6815***	-0.7036***	-0.7094***	-0.6813***
	(0.0145)	(0.0143)	(0.0134)	(0.0145)	(0.0143)	(0.0134)
cons	4.3642***	4.4977***	3.3766***	4.3643***	4.4962***	3.3883***
	(0.0994)	(0.1012)	(0.0989)	(0.0994)	(0.1011)	(0.0991)
N	278416	283137	332286	278416	283137	332286
adj.R2	0.474	0.474	0.479	0.474	0.474	0.480

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include city and industry–year fixed effects.

6. Conclusion and Discussion

The air pollution that has accompanied China's rapid development has called for both public attention and government mitigation efforts. Based on a unique data set of firm-level pollution paired with a database of political elites, this study investigates the political roots behind China's abnormally high levels of pollution and subsequent mitigation efforts. This can help us to better understand how the personal connections of political elites influence local air pollution intensity in China based on firm-level evidence. We have presented three main sets of results.

First, we show that local officials who have personal ties to the leader of a province tend to have more SO2-intensive enterprises under their governance. This finding is further substantiated by identifying the causal relationship between political connection and higher pollution, as firms newly opened under the governance of secretaries or mayors with personal connections are more polluting than those under local leaders without such connections. We also use the tenure of provincial secretaries as an IV of political connections, which helps us further identify the causality between air pollution and personal connections of political elites. This study conducts additional robustness tests on several other metrics and pollutants, including COD, ammonia nitrogen, waste gas, and industrial dust, which show similar results as SO2 in the baseline analysis.

Second, we conduct heterogeneity tests for different ownership and firm sizes. The results show that political connections significantly increase the pollution intensity among domestically owned firms as compared with foreign-owned firms. The results also show that political connections increase pollution intensity for large, medium, and small firms.

Third, this study conducts a number of extension analyses to investigate the mechanisms behind Chinese pollution governance and performance, including reasons for appointment of local leaders to a given city (i.e., to cities with favorable conditions as a reward rather than to polluting cites as a test of ability), career incentives, and pollution resulting from corruption. We give statistical evidence that politically connected officials are assigned to more productive cities with more favorable conditions, and we rule out the possibility that they have been appointed to more polluted regions as a test of ability. We show that career incentives are a reason behind high pollution (prior to 2006) and its mitigation (after 2006) using an empirical strategy similar to the DID method, finding that local officials have transferred their targets from polluting growth to environmental protection after the changes in promotion criteria. We also find that enterprises in cities with corrupt mayors or secretaries have higher SO2 intensity than those without, that air pollution is further exacerbated if corrupted officials have patronage connections.

The findings of this study shed light on the political roots of China's pollution and highlight the role of political institutions in environmental management and pollution mitigation. One implication of our findings is that the

personal connections of political elites encourage more pollution through favorable resources and political protection from their patrons, which should be addressed through methods such as central government administrative inquiry, political turnover, or public monitoring. Another implication is that a more inclusive set of promotion criteria are necessary, such that local officials will pay more attention to environmental issues rather than prioritize economic growth at all costs. The results show that the role of personal connections between political elites can be different at different stages, which transcends the traditional "pollution for promotion" idea. Patronage connections encourage bold pollution behavior when economic growth is the sole target of higher level government, and encourage harder work in pollution mitigation when green development and environmental protection is prioritized by patrons. Personal connections "grease the wheels" and help upper- and lower-level officials align their targets through informal institutions.

This is certainly only part of the story, considering the recent mass transition of polluting industries and factories between cities and provinces, including both the relocation of polluted industries and the reallocation and outsourcing of polluted intermediate products. Future research should dig deeper into how formal and informal political institutions influence the outsourcing of highly polluting products and help us better understand the pollution haven effect through a political economy perspective.

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Appendix A. Robustness Checks for SO2 Intensity and Political Connections

In Table 2 we present the baseline results on the effect of political connections on enterprise SO2 intensity. In Table A1 we additionally present the results between city secretaries or mayors and provincial governors.

Table A1: SO2 Intensity and Political Connections: Province Governors

	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2	lnSO2
	(1)	(2)	(3)	(4)	(5)	(6)
mayor	0.0227***			0.0276***		
	(0.0072)			(0.0073)		
secretary		0.0412***			0.0456***	
		(0.0090)			(0.0091)	
mayorорsecretary			0.0510***			0.0574***
			(0.0072)			(0.0072)
InOutput	-0.6243***	-0.6243***	-0.6431***	-0.6214***	-0.6213***	-0.6395***
	(0.0031)	(0.0031)	(0.0030)	(0.0031)	(0.0031)	(0.0030)
InEmployee	0.3517***	0.3517***	0.3661***	0.3496***	0.3497***	0.3635***
	(0.0045)	(0.0045)	(0.0043)	(0.0045)	(0.0045)	(0.0043)
open	0.0018***	0.0018***	0.0024***	0.0017***	0.0016***	0.0021***
	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0002)
export	-0.7283***	-0.7281***	-0.7068***	-0.7078***	-0.7075***	-0.6819***
	(0.0141)	(0.0141)	(0.0134)	(0.0141)	(0.0141)	(0.0134)
cons	4.1150***	4.1107***	3.0306***	4.4551***	4.4493***	3.3960***
	(0.0493)	(0.0493)	(0.0488)	(0.0928)	(0.0928)	(0.0989)
City	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes			
Y ear	Yes	Yes	Yes			
Industry x Year				Yes	Yes	Yes
N	291394	291394	332286	291394	291394	332286
adj.R2	0.471	0.471	0.475	0.475	0.475	0.480

Note: The significance levels of 1%, 5%, and 10% are denoted by ***, ** and * respectively. Standard errors are presented in parentheses. Regressions include city, industry and year fixed effects in columns 1, 2, and 3, and include city, industry-year, and year fixed effects in columns 4, 5, and 6.

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is are presented in parentheses. Regressions include city, industry, and year fixed effects in columns 1, 2, and 3, and city, industry–year, and year fixed effects in columns 4, 5, and 6.

This study also considers other types of connections, namely, local leaders having the same university and hometown as higher-level officials. The results are provided in the appendix as Table A2.

Table A2: SO2 Intensity and Political Connections: Education and Hometown

	Education Experience				Hometown			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
secretary	0.1027***		0.1070***		-0.0771**		-0.0830***	
	(0.0237)		(0.0237)		(0.0307)		(0.0309)	
mayor		0.0470		0.0530		-0.1295***		-0.1233***
		(0.0322)		(0.0323)		(0.0464)		(0.0463)
InOutput	-0.6227***	-0.6226***	-0.6211***	-0.6211***	-0.6226***	-0.6226***	-0.6211***	-0.6211***
	(0.0036)	(0.0036)	(0.0036)	(0.0036)	(0.0036)	(0.0036)	(0.0036)	(0.0036)
InEmployee	0.3201***	0.3201***	0.3179***	0.3179***	0.3200***	0.3200***	0.3178***	0.3179***
	(0.0052)	(0.0052)	(0.0052)	(0.0052)	(0.0052)	(0.0052)	(0.0052)	(0.0052)

open	0.0024***	0.0024***	0.0023***	0.0023***	0.0024***	0.0024***	0.0023***	0.0023***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Export	-0.7862***	-0.7860***	-0.7708***	-0.7707***	-0.7855***	-0.7858***	-0.7702***	-0.7705***
	(0.0167)	(0.0167)	(0.0167)	(0.0167)	(0.0167)	(0.0167)	(0.0167)	(0.0167)
cons	4.2333***	4.2428***	4.7117***	4.7223***	4.2411***	4.2419***	4.7208***	4.7207***
	(0.0631)	(0.0630)	(0.1716)	(0.1716)	(0.0630)	(0.0630)	(0.1717)	(0.1717)
N	212649	212649	212649	212649	212649	212649	212649	212649
adj. R2	0.479	0.479	0.482	0.482	0.479	0.479	0.482	0.482

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. Regressions include city, industry, and year fixed effects in columns 1 to 4, and city, industry–year, and year fixed effects in columns 5 to 8.

Appendix B. Heterogeneity Tests for SO2 Intensity and Political Connections

There are large geographic and demographic differences across China. For instance, east and coastal provinces are more developed regions, while west and inland provinces are developing regions. This study separates the full sample into three groups: eastern provinces including Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, and Hainan; middle provinces including Shanxi, Neimenggu, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, and Guangxi; and western provinces including Sichuan, Chongqing, Guizhou, Yunnan, Xizang, Shannxi, Gansu, Ningxia, Qinghai, and Xinjiang. The results in Table 8 show that patronage connections of local leaders in eastern and middle provinces increase SO2 intensity under their governance, while the effects in western provinces are not statistically significant.

Table B1: SO2 Intensity and Political Connections: by Geographical Regions

	Eastern Provinces			Middle Provinces			Western Provinces		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
mayor	0.0265***			0.0425***			-0.0052		
	(0.0096)			(0.0130)			(0.0220)		
secretary		0.0227**			0.0151			0.0193	
		(0.0099)			(0.0136)			(0.0219)	
mayorорsecretary			0.0281***			0.0441***			0.0171
			(0.0100)			(0.0131)			(0.0225)
InOutput	-0.6148***	-0.6148***	-0.6148***	-0.6092***	-0.6091***	-0.6091***	-0.6686***	-0.6687***	-0.6687***
	(0.0040)	(0.0040)	(0.0040)	(0.0057)	(0.0057)	(0.0057)	(0.0092)	(0.0092)	(0.0092)
InEmployee	0.2634***	0.2635***	0.2635***	0.4417***	0.4417***	0.4416***	0.4970***	0.4970***	0.4970***
	(0.0058)	(0.0058)	(0.0058)	(0.0083)	(0.0083)	(0.0083)	(0.0131)	(0.0131)	(0.0131)
open	0.0030***	0.0030***	0.0030***	--		-0.0011**	0.0038***		0.0038***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0007)	(0.0007)	(0.0007)
export	-0.7900***	-0.7901***	-0.7899***	-0.2961***	-0.2951***	-	-	-	-
	(0.0157)	(0.0157)	(0.0157)	(0.0362)	(0.0362)	(0.0362)	(0.0735)	(0.0735)	(0.0735)
cons	5.2422***	5.2420***	5.2412***	3.5198***	3.5252***	3.5188***	3.3382***	3.3299***	3.3299***
	(0.1992)	(0.1991)	(0.1991)	(0.1231)	(0.1234)	(0.1230)	(0.1911)	(0.1908)	(0.1913)
N	166349	166349	166349	81925	81925	81925	43120	43120	43120
adj.R2	0.488	0.488	0.488	0.464	0.464	0.464	0.444	0.444	0.444

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include city, industry–year, and year fixed effects.

There is also heterogeneity between different sectors. This study separates the full sample into three sectors: mining industries, manufacturing industries, and the supply of electricity, heat, and water.

Table B2: SO2 Intensity and Political Connections: by Sectors

	Mining			Manufacturing			Electricity, Water and Heat		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
mayor	0.0345			0.0258***			-0.0746*		
	(0.0379)			(0.0073)			(0.0412)		
secretary		-0.0169			0.0196***			0.0039	
		(0.0385)			(0.0075)			(0.0391)	
mayorорsecretary			0.0007			0.0322***			-0.0196
			(0.0387)			(0.0074)			(0.0416)
InOutput	-0.6316***	-0.6315***	-0.6128***	-0.6276***	-0.6276***	-0.6474***	-0.3382***	-0.3383***	-0.3383***
	(0.0188)	(0.0188)	(0.0182)	(0.0032)	(0.0032)	(0.0031)	(0.0191)	(0.0191)	(0.0180)
InEmployee	0.4266***	0.4268***	0.4293***	0.3442***	0.3442***	0.3592***	0.3030***	0.3027***	0.3027***
	(0.0219)	(0.0219)	(0.0215)	(0.0047)	(0.0047)	(0.0045)	(0.0297)	(0.0297)	(0.0286)
open	0.0046***	0.0046***	0.0044***	0.0013***	0.0013***	0.0013***	-0.0028	-0.0027	-0.0026
	(0.0012)	(0.0012)	(0.0011)	(0.0003)	(0.0003)	(0.0002)	(0.0018)	(0.0019)	(0.0018)
export	-0.0184	-0.0193	0.0842	-0.7031***	-0.7031***	-0.7031***	-2.4691	-2.4666	-1.8762
	(0.3353)	(0.3356)	(0.2993)	(0.0141)	(0.0141)	(0.0134)	(1.6095)	(1.6119)	(1.4347)
cons	4.6920***	4.6920***	1.4597***	4.6769***	4.6769***	4.6750***	3.5868***	5.9361***	5.9463***
	(0.5256)	(0.5259)	(0.3256)	(0.0639)	(0.0639)	(0.0654)	(0.3148)	(0.3148)	(0.2179)
N	10663	10663	11904	273109	273109	311725	7622	7622	8657
adj.R2	0.429	0.429	0.416	0.459	0.459	0.465	0.388	0.388	0.389

Note: Significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively. Standard error is presented in parentheses. All regressions include city, industry–year, and year fixed effects.