BOFIT Discussion Papers
4 • 2019

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Political connections and firm pollution behaviour: An empirical study

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BOFIT Discussion Papers
Editor-in-Chief Zuzana Fungáčová

BOFIT Discussion Papers 4/2019
27.2.2019

Yuping Deng, Yanrui Wu, Helian Xu: Political connections and firm pollution behaviour: An empirical study

ISBN 978-952-323-266-2, online
ISSN 1456-5889, online

Suomen Pankki
Helsinki 2019

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Abstract

A firm's top manager and a government official may be connected due to special circumstances. This social relationship or political connection may provide industrial polluters with protection or a "pollution shelter" which could lead to severe environmental deterioration. This paper aims to examine the link between political connections and firms' pollution discharges by using Chinese data. Empirical results show that political connections are the institutional origin for firms to adopt strategic pollution discharges. Government officials who are young, of low education, promoted locally and in office for a relatively long time are more likely to build political connections with polluters. This phenomenon results in inadequate enforcement of regulation and emission control. The pollution discharges of politically connected firms also vary considerably due to firm heterogeneity. This study also shows that pollution shelter effects caused by political connections are more obvious in the central and western regions, prefecture cities and capital-intensive industries.

Keywords: political connections; pollution discharges; political promotion; China
JEL codes: Q51; L20; O12

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Work in this paper was supported by the National Natural Science Foundation of China [# 71703035], China Scholarship Council (# 201706135020), Bank of Finland Institute of Transition (BOFIT) and East Asian Institute (EAI) National University of Singapore. The authors gratefully acknowledge the helpful comments from Zuzana Fungáčová and participants of seminars and workshops at BOFIT, EAI, ADEW2018, Yunnan Normal University and Hohai University.

1 Introduction

Since the launch of economic reforms and open-door policy, China has achieved phenomenal economic growth which is regarded as an unprecedented development miracle. However, the past growth model with high inputs and pollution brings about serious environmental problems such as heavy city smog, discharging of pollutants without permission and increased cases of cancer in villages. In terms of pollution control, China's political promotion system, which uses GDP growth as its core criterion, acts as a powerful factor that prompts government officials and firms' top managers to form political connections. This social relationship provides polluters with protection and indulgence (hereafter referred to by the term "pollution shelter") which may lead to severe environmental deterioration. Thus it is necessary to comprehensively evaluate firms' environmental performance from the perspective of political connections. The knowledge gained would be helpful for the construction of a resource-conserving and environmentally friendly society, as well as the reform of the government administration system in the country.

In this paper, we aim to investigate the relationship between political connections and firm pollution behaviour. Our empirical results show that political connections between local government officials and firms' top managers are the institutional origin that causes firms to adopt strategic pollution discharge, and that political connections are associated with an increase in firms' pollution discharges. Government officials with less education, a younger age, relatively longer tenure and local promotion are more likely to build political connections with polluters, which result in insufficient regulation and control for excessive emissions. Furthermore, it is shown that the pollution shelter effects caused by political connections are more obvious in central and western regions, prefecture cities and capital-intensive industries.

This paper contributes to the existing literature in the following three aspects. First, it broadens the definition of political connections by following a social network approach and then explores firms' strategic pollution discharge from the perspective of political connections. Political connections are defined as the links between politicians and firms' top managers in non-contractual social relations based on their birthplace. In existing studies political connections are defined as having a senior executive or board member who is a current or former government official (Fan et al., 2008; Faccio, 2010; Cai & Sevilir2012; Zhang, 2017; Zheng et al., 2017; Su et al., 2018), having financially donated to a political party (Khwaja & Mian, 2005; Claessens et al., 2008; Cooper et al., 2010; Zhang et al., 2016), or a representative in the National People's Congress (NPC) or Chinese People's Political Consultative Conference (Fan et al. ,2008; Cai & Sevilir, 2012; Li & Zhou, 2015; Schweizer et al., 2017). However, this type of measurement is rough and inaccurate, especially for China (Cheng, 2018). The reason is that if the senior executives or board members worked for the

government a long time ago, then their political power may disappear. Thus connections with a former official who served farther back in time have negligible effects on firm activities (Faccio, 2006). Some authors adopt the state ownership of firms as a proxy for political connections (Berkman et al., 2010; Maung et al., 2016; Zhang, 2018). Since the top managers of state-owned firms maintain close ties with the government, so their motivation to build political connections is determined endogenously by the consequences of political connections (Do et al., 2015). In light of this we focus on political connections through the social network of birthplaces which are identified for all politicians and top managers. We also measure political connections through the social network of alumni as proposed by Engelberg et al. (2013), Zhu & Chung (2014) and Do et al. (2015).

The second significant contribution is that micro-data are used to control for heterogeneity in politicians and firms, and examine the different influences of political connections on firm emission behaviour. To the best of our knowledge, several papers examined the determinants of environmental pollution at the firm level. They focused on whether exporting firms performed better environmentally than their non-exporting competitors (Cole et al. ,2013; Cui et al. ,2016; Richter & Schiersch, 2017; Forslid et al. ,2018), or tested whether foreign firms were cleaner than their domestic competitors (Wang & Jin, 2007; Jiang et al.,2014). However none of these studies has established a link between political connections and firms' pollution discharges. Two papers investigated the difference between politically connected firms and non-politically connected ones in environmental performance, which are most closely related to our work. The first paper by Zhang (2017) uses a panel dataset of China's listed firms to examine how political connections affect corporate environmental responsibility. In this paper political connections are defined according to whether the chief executive officer (CEO) of a list firm is a current or former official. The second paper by Maung et al. (2016) analyzes how state ownership of non-listed firms affects pollution fees. In this paper, state ownership is considered as a proxy for firms' political connections. Their empirical results show that firms with state ownership pay lower environmental levies. In the present study, we further explore the impact of politician and firm characteristics on the relationship between political connections and firms' pollution discharges.

Third, although a growing body of literature has established a link between political connections and firm performance, it is still not very clear how political ties affect firms' pollution behavior. In this paper we go a step further to investigate how political connections affect firms' pollution discharges through resource misallocation and unfair enforcement of environmental regulation. This paper therefore adds theoretical and empirical support to the "political resource curse" proposed by Brollo et al. (2013). We find that political connections lead firms to invest excessively and hence lead to resource misallocation. Meanwhile, political connections cause the weakening of

the enforcement of environmental regulations and consequently an increase in firm pollution discharges. These two mechanisms reasonably explain the phenomenon that our emission control gets more and more stringent while reduction performance is still unsatisfactory.

The remainder of this paper is structured as follows. Section 2 presents the literature review and hypothesis development. Section 3 demonstrates the model specification and describes the data and choice of the variables. Section 4 presents empirical results, while Section 5 ends with conclusions and policy recommendations.

2 Literature review and hypothesis development

2.1 Literature review

Political connections include both formal and informal relationships built by local officials and firms (Bertrand et al., 2007). Through political connections, firms have access to scarce and valuable political resources controlled by local governments. Research has revealed that politically connected firms significantly benefit from favourable financing (Faccio, 2010; Duchin & Sosyura, 2012), tax privileges (Mobarak & Purbasari, 2006; Kim & Zhang, 2016; Chen et al., 2016), government subsidies (Faccio et al., 2006; Montmartin, 2013), and debt relief (Boubakri et al., 2008; Bliss & Gul, 2012). Additionally, through embedding themselves in politically connected networks, firms' top managers can win government support by participating in government decision-making (Faccio, 2006; Goldman et al., 2009), receive honours and awards (Hwang & Kim, 2009; Polsiri & Jiraporn, 2012; Cingano & Pinotti, 2013), and have access to simplified approval procedures (Faccio, 2006; Wang & Sheng, 2010). However, firms need to dedicate major resources to build and maintain political connections which undoubtedly increase their operating expenses. There are several reasons for this. First, political resources are not provided free-of-charge, but at the cost of transferring political rents to local officials (Fan et al., 2008; Cheung et al., 2010). Second, political connections would result in the objective function of a firm being dominated by government priorities, ultimately reducing investment efficiency and triggering over-investment (Li & Zhou, 2005; Chen et al., 2011; Xu et al., 2013). Finally, once political connections can be transformed into competitive advantages, firms will have little incentive to improve operational efficiency and deliver cost savings (Peng et al., 2009; Cai & Sevilir, 2012; Baranchuk et al., 2014).

In recent years, the analysis of government competition has been a new frontier of research on environmental issues which investigates how fiscal decentralization and political incentives affect the environment (e.g. Konisky, 2009; Millimet & Roy, 2015). Some studies show that local government will compete for resources by lowering environmental standards in order to attract new

firms and create more jobs. This "race to the bottom" in environmental regulation will lead to the deterioration of the environment (List et al., 2004; Ogawa & Wildasin, 2009; Dong et al., 2015; Bu & Wagner, 2016). Numerous studies have also shown that developed countries voluntarily lower environmental standards or relax environmental regulation in order to maintain competitiveness in pollution-intensive industries (Benarroch & Thille, 2001; Konisky, 2007; Manderson & Kneller, 2012; Chung, 2014). The empirical evidence from the U.S. indicates that the environmental "race to the bottom" does exist in all states (Xing & Kolstad, 2002; Woods, 2006; Millimet & Roy, 2015), and that environmental spillovers encourage local governments to adopt a "free-rider" approach in transboundary pollution treatment (Gray & Shadbegian, 2004; Sigman, 2007; Sanna-Randaccio & Sestini, 2012; Banzhaf & Chuppd, 2012). It is also argued that Chinese decentralization, a combination of political centralization and fiscal decentralization, is the institutional background for understanding the insufficient supply of environmental public goods (Qian & Roland, 1996; Blanchard & Shleifer, 2000; Cai & Treisman, 2006; Wang & Chen, 2014). A growing body of literature reveals that fiscal decentralization and GDP growth assessment have prompted local governments to irrationally compete in the realm of environmental policies (Marquis et al., 2011; He et al., 2012). Thus, binding emission reduction targets cannot fundamentally correct the "race to the bottom" behaviour and stop the strategic endeavour of government officials (Zheng et al., 2014; Ghanem & Zhang, 2014; Guo & Shi, 2017).

However, the existing literature mainly focuses on the costs and benefits of political connections and the effects of local government competition on the environment. It fails to analyse the role of government officials who are the decision makers. The literature also ignores how the official governance system plays a moderating role in the relationship between local government behaviour and environmental pollution. In addition, previous studies neglect the special circumstances of forming political connections and take insufficient account of the differences in individuals such as officials and top managers.

2.2 Hypothesis development

After nearly 40 years' endeavour, China has formed a disciplinary environmental management system featuring unified supervision and management by environmental protection departments and assignment of responsibility to local governments under the unified leadership of the central government. This management system has effectively promoted the development of environmental protection in the transition period of the economy. However, for decades, China's economic boom has been accompanied by growing pollution and the emergence of environmental management problem. One outstanding problem is the inconsistency of environmental behaviour between central and local

governments. Specifically, due to fiscal decentralization, a local government actually plays the role of a double agent. On the one hand, local government, as the agent of central government, is responsible for implementing and monitoring environmental policies formulated by the central government. On the other hand, local government, as a jurisdictional agent, bears the burden of promoting the regional economy. The political promotion tournament, which mainly relies on GDP growth assessment, prompts local officials to engage in fierce competition over economic growth (Zheng et al., 2014; vander Kamp et al., 2017). Thus, junior officials may be more likely to encourage polluting firms to operate in their jurisdictions. Meanwhile, their superiors have strong motivation to relax environmental regulations to protect their subordinates from being investigated and prosecuted. By doing so, they can minimize legal costs and realize common goals for economic growth in their jurisdictions (Zhu et al., 2013; Wu et al., 2014; Yu et al., 2019).

Moreover, the environmental enforcement authority in China is affiliated with local environmental protection agencies, while the leaders of these agencies are appointed by local governments. Thus, environmental enforcement may be subjected to local government authority (Faccio, 2006; Li et al., 2008). This forms the basis for local government officials and firms' top managers to build political connections, for which same-hometown or birthplace identity acts as the particular node (Zhang et al., 2016). In contrast to the cultural orientation prevalent in the West, China is a highly relationship-oriented society with a unique institutional environment that has been influenced by both its history and political ideology (Guo et al., 2018). The Confucian philosophy emphasizes strong geographical relationship, which is an effective way of obtaining resources and reducing transactional costs (Fan, 2002; Chan & Suen, 2005). Top managers are strongly socialized groups, and their birthplaces are undoubtedly one important dimension to form personal relationships. In such a case, same birthplace identity plays a critical role in political connections. For an official with a well-connected family background, same birthplace identity is a beneficial channel to develop interpersonal network. For a grass-root official who has no political affiliations, same birthplace identity is the most convenient ticket to enter into the upper-class circles. Thus, once political connections are established, officials may share their political resources with their connected firms (Chen & Li, 2012; Li & Xu, 2016). This type of political connections provides protection for the polluters or a pollution shelter. Therefore, fiscal decentralization and political promotion tournaments imply that local government officials have strong motivation to form political connections with local firms which undermine China's environmental protection efforts. Thus our first hypothesis is:

Hypothesis 1: Political connections between local officials and firms' top managers increase pollution discharges.

Political connections may influence the environment in two ways, namely resource misallocation and environmental regulation. As China has not yet formed a market-based resource allocation system, local governments control key resources (Chen et al., 2011; Jiang & Tan, 2013; Feng et al., 2018). These resources could be allocated according to firms' political proximity rather than their productive efficiency (Khwaja & Mian, 2005; Deng et al., 2017). In this context, establishing good relationships with local governments enables firms to improve their political proximity. Local governments may give priority to politically connected firms for political purposes or personal benefits. Accordingly, politically connected firms can obtain some significant resources which affect their development and hence their production decisions. These effects may cause resource misallocation. Resource misallocation may lead firms to invest excessively and therefore generate more pollution discharges. On the one hand, politically connected firms are easier to get long-term loans from the banks and relax their financial constraints (Li et al., 2008; Li & Zhou, 2015). On the other hand, it is shown that political connections cause firms' goals to be dominated by government priorities and result in investment inefficiency (Bliss and Gul, 2012; Boubakri et al., 2012; Piotroski & Zhang, 2014).

In a transitional economy like China, various institutional distortions, such as ambiguous property rights, poorly developed environmental institutions and soft budget constraint, provide further opportunity for local officials to intervene in business decisions. In order to get promoted, local government officials tend to link their own political goals with investment decisions of politically connected firms through a series of preferential policies and administrative permissions (Chen et al., 2008; Duchin and Sosyura, 2012; Blau et al., 2013). The politically connected firms may expand their investment to maintain good relationships with local government officials and gain their support for access to key resources. To cater for local officials' interests, politically connected firms become accustomed to carrying excessive investment to boost local economic growth, which leads to overcapacity (Aggarwal et al., 2011; Duchin & Sosyura, 2012; Cerqua & Pelliergrini, 2014). Over-investment requires even more consumption of limited resources and hence may cause insufficient investment in environmental protection. Thus, we propose the following hypothesis:

> *Hypothesis 2a. Political connections cause resource misallocation that can subsequently increase firms' pollution discharges*

In addition to resource misallocation, political connections may encourage local officials to relax environmental regulations and even indulge in pollution, thus deteriorating the environment (Wu et al., 2014). Politically connected firms may bribe local government officials so that they can get away with environmental regulation and penalties. In order to promote regional economy, local government officials are motivated to inadequately implement or distort environmental policies Jia

(2013) constructed a multi-task principal-agent model to analyse how promotion incentives of provincial governors affect pollution. His theoretical analysis indicates that a higher relative price of clean technologies increases the use of dirty technologies due to a substitution effect, but political connections further strengthen the substitution effect. In addition, political connections can also provide an opportunity for firms to modify or influence environmental policy and future regulations in their favor (Lyon & Maxwell, 2008; Zhang, 2017). In other words, politically connected firms may lobby or bribe local government officials to accept lower environmental standards. Through their political connections, some firms even convey unverifiable information to decision-makers as they cannot fulfill high environmental standards and force governments to relax the standards. In this case, relaxed environmental regulations lower the barrier to entry for heavy polluters and reduce the willingness for emission reductions which harm sustainable development. Therefore, the following hypothesis is formulated:

Hypothesis 2b: Political connections weaken the enforcement of environmental regulations and consequently increase firms' pollution discharges.

3 Research design

3.1 Empirical specifications

The main econometric specification in this study is related to Zhang (2017), who used chief executive officer who is a current or former government bureaucrat to define a firm's political connection and examined its relationship with corporate environmental responsibility.

To test Hypothesis 1, the following panel data model is considered:

$$Pollution_{it} = \alpha_0 + \alpha_1 Political_{it} + \sum \beta_k Control_{it} + \beta_t Year_t + \beta_j City + \beta_m Industry_m + \varepsilon_{it} \quad (1)$$

where the subscripts denote firm *i,* city *j ,* industry *m,* control variable *k* and year *t*. *Pollution* is an indicator of environmental pollution, *Political* is the index of political connections, and *Control* denotes control variables that affect pollution. The dummy variables of year, city and industry are also included to control for unobserved fixed effects that are correlated with the main regressors, and ε is the residual term.

To test Hypothesis 2, model (1) is extended as follows:

$$Pollution_{it} = \alpha_0 + \alpha_1 Political_{it} + \alpha_2 Z_{it} + \alpha_3 Political_{it} \times Z_{it} + \sum \beta_k Control_{it} + \beta_t Year_t + \beta_j City + \beta_m Industry_m + \varepsilon_{it} \quad (2)$$

where *Z* denotes the channel through which political connections influence the environment. These channels in turn include resource misallocation (*Misallocation*) and environmental regulation (*Regulation*).

3.2 Data sources

For this study, we matched the hometown information of 643 mayors during the period of 2007-2015 with the unbalanced panel data of the listed firms in China. Data are drawn from several sources. First, the database of the Institute of Public and Environmental Affairs (IPEA) provides information about environmental records of about 300,000 firms during 2004-2016. This database discloses firms' pollution information provided by the Ministry of Environment Protection (MEP) for 338 prefecture-level cities and counties. In practice, firms are required to self-report their emissions and then inspected by the MEP each year. Each firm files an emission form to provide its pollution discharges. After monitoring and inspecting by MEP, the form will be then uploaded in the website of IPEA. The emission form is very detailed and consists of six sets of questions: (1) basic information about the firms such as firm address, industry category, main products, main types of pollution and discharge standards; (2) the volume of water used for production and volume of waste water discharge (including chemical oxygen demand, ammonia nitrogen and suspended solids); (3) the volume of gas discharge (including sulfur dioxide, nitrogen oxide, industrial dust and soot); (4) carbon dioxide emissions and energy consumption (including soft coal, diesel, natural gas, power consumption, etc.); (5) the volume of general industry solid waste and hazardous waste; (6) supplementary information (including original monitoring report and confirmation letter).

Since the pollution information provided by IPEA needs to be manually collected, it has not been widely used in the existing literature. To the best of our knowledge, Liang & Gao (2014) used the frequency of notification for enterprises with pollutants over-discharged to measure regional pollution. Shen et al. (2017) collected the information of environmental violation records with the help of Python software to examine whether environmental regulation caused pollution to be relocated nearby. Zhang et al. (2018) adopted the Pollution Information Transparency Index published by the IPEA to test the effects of environmental regulation on firms' value. Li & Huo (2018)

used the data of environmental fines collected by IPEA to examine the relationship between managerial competence and corporate environmental information disclosure.

Second, the China Stock Market Accounting Research (CSMAR) database contains information on corporate top managers such as birthplace, age, educational background, work experience, sector and ownership of listed companies, and other financial indicators. Hereby, top managers reported in the CSMAR database consist of board members and senior executives. The former include executive directors and independent directors. The executive directors include executive officers, large shareholders and representatives of other stakeholders such as labor unions, board of supervisors, and so on. The senior executives include general managers or presidents, vice general managers or vice presidents, chief financial officers or financial managers, legal representatives, and so on. According to the names and registered addresses of listed companies, the IPEA and CSMAR databases are matched. Third, the biographical information about politicians is mainly sourced from several websites such as *people.com*, *xinhuanet.com* and *Baidu Encyclopedia*. These sites have information about politicians' birthplace, age, educational background, work experience, tenure and professional qualifications.

Finally, city data are collected from the China Economic Information Network Statistics Database, which includes the names of the cities in each province, their GDP per capita, fiscal revenues and expenditures.

The raw data were filtered according to several criteria. First, observations with negative pollution volumes or without any pollution information were deleted. Second, observations were deleted if the net value of fixed assets and total assets is either negative or zero or if the net value of fixed assets is larger than total assets. Third, the listed companies without their top managers' biographical information are excluded. Finally, the observations have at least two years of data available in the database. After cleaning, the final sample comprises 3,988 firms with 15,238 firm-year observations covering the years of 2007 to 2015. Capital variables are deflated by using the price index of investment in fixed assets with a base year of 2000, and GDP per capita are deflated by using GDP price index

3.3 Variable definitions

The dependent variable is environmental pollution (*Pollution*). In the literature, pollutant intensity and pollutant emissions are widely used to measure environmental pollution. Pollutant emissions reflect the total amounts of discharge as a result of economic activities, while pollutant intensity reflects emissions relative to economic activities. In this paper we mainly focus on sulfur dioxide intensity (SO2 for short) as a measure of environmental pollution. The intensity of industrial SO2

emissions is defined as SO2 emissions over the value of sales. The main reasons are as follows: one the one hand, SO2 is considered the most threatening environmental pollution generated by China's manufacturing sector, and it has been widely used as a major indicator to measure environmental pollution (He & Wang, 2012; Jiang et al., 2014; Li, et al., 2015; Zeng et al., 2018); On the other hand, the information provided by IPEA is much more complete than other pollutant types in the dataset, and can effectively ensure data consistency and hence may help obtain better results.

The main independent variable is political connections (*Political*). The existing literature uses a proxy variable to measure political connections in the form of the political background of firms' top managers or personal relationships (Bertrand et al., 2007; Li et al., 2008; Faccio, 2010; Cai & Sevilir, 2012). In China, personal connection between individuals with the same hometowns or birth places can often be established easily. In this paper, it is thus defined that, if the local official has the same birthplace as one of the top managers of a listed company located in the official's jurisdiction, then the political connection variable takes the value of one and zero otherwise. The underlying assumption is that the official and top manager are connected due to being born in the same place.

During data processing, it was found that some top managers and officials only provided their birthplaces at the prefecture level. The registered address of a company is also detailed at the prefecture level. In the Chinese administration system, at the prefecture level, the secretary of the Communist Party is mainly responsible for party organizations and performance management, and the mayor runs the daily management of the economy. In view of this arrangement, we focus on the political connections between the city mayor and the top manager of the firms located in that city. For robustness checks, we also consider two optional definitions of political connections. First, we use the birthplace information at the provincial level to define political connections. Thus, *Political_province* takes the value of one if the local official shares the same birthplace as the top manager at the provincial level and zero otherwise. Second, we define political connections on the basis of whether a company's top manager and the mayor graduated from the same university. That is, if one of the top managers of a listed firm graduated from the same university as the mayor in whose district the company is located, then political connection variable *Political_school* takes the value of one, and zero otherwise.

To minimize estimation biases due to omitted variables, we add some firm-specific control variables that may affect pollution. These control variables are illustrated as follows.

Liability ratio (*Liability)*. A high liability ratio significantly reduces the capacity of firms to repay their debts and leads to insufficient funding to fulfil environmental responsibility. We use the ratio of total debts over total assets as a measure of liability ratio.

Profitability is another factor influencing polluters' performance. Generally speaking, with better profitability, firms are inclined to spend more on the environmentally friendly facilities and technologies and eventually reduce their pollution discharge. In this paper, profitability is measured by the ratio of net profits over net assets.

Firm scale (*Scale*) also affects emission efficiency. A large company may pay greater attention to its social image and long-term development, and hence undertakes more initiatives to fulfil its environmental responsibility. However, the expansion of scale may lead to a larger demand for energy and resources. The firm scale is measured by the natural logarithm of total assets.

Property rights (*Ownership*). State-owned enterprises (SOEs) keep close contact with local governments and have great bargaining power in negotiating pollution discharges (Wang & Jin, 2007). Thus, property rights may have a profound influence on the environment. Following An et al. (2016), Xu et al. (2016) and Su et al. (2018), we divide the firms into SOEs and non-SOEs according to their ultimate controllers. SOEs are defined as firms whose ultimate controller with more than 50% equity is the state while non-SOEs are defined as firms whose ultimate controllers are others. The dummy variable *Ownership* takes the value of one for SOEs and zero for non-SOEs.

In line with Cole et al. (2013) and Jiang et al. (2014), we use population density (*Population*), per capita income (*Pgdp*) and industrial structure (*Manufacturing*) to control for city-level characteristics.

Population is measured by the number of people per unit area. High population density will produce more pollution on the one hand and lead more people to participate in environmental protection on the other hand.

GDP per capita (*Pgdp*) is an important variable that affects environmental pollution. The relationship between GDP per capita and environmental pollution may show an inverse U-shape (Grosman & Krueger, 1995), so we use quadratic forms to describe the impact of output per capita on environmental pollution.

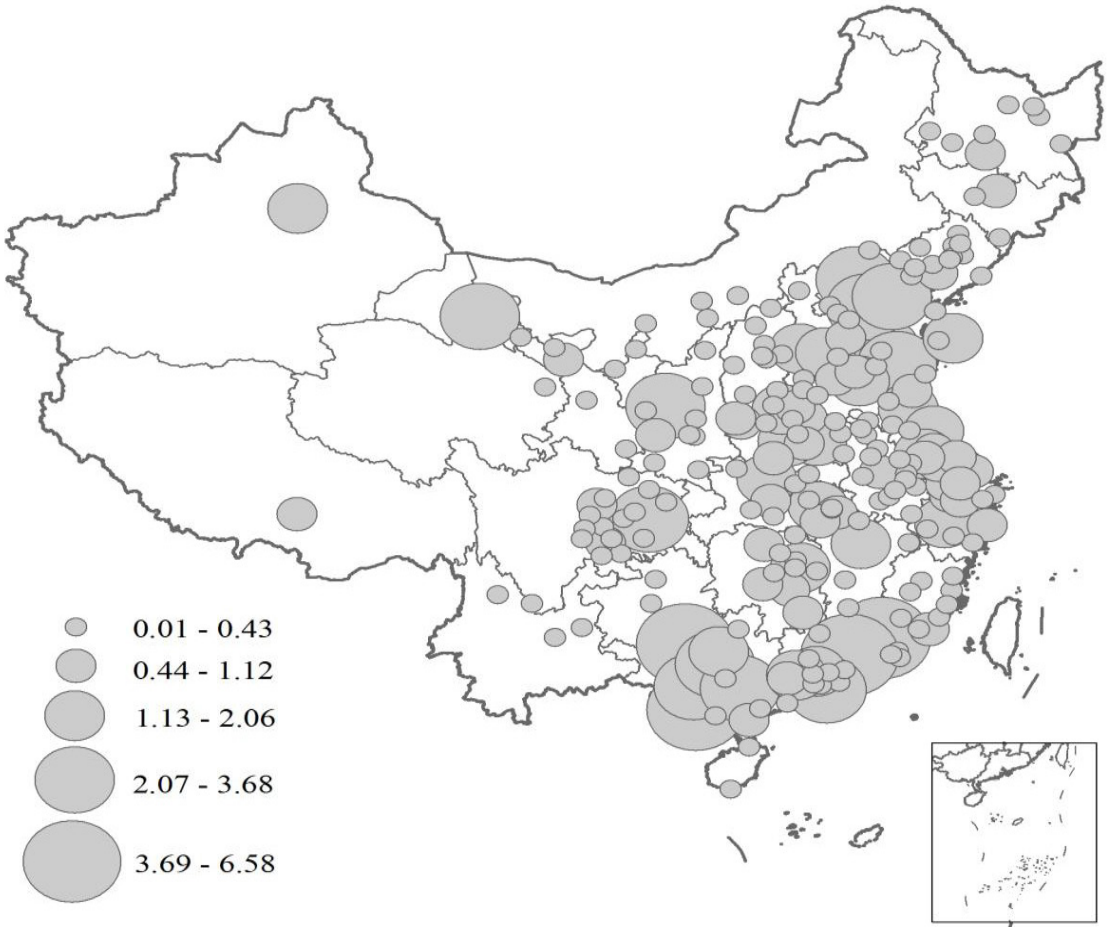
Industrial structure (*Manufacturing*) is measured by the ratio of industrial added value in manufacturing to GDP. Quickening industrialization leads to the unrestrained exploitation of natural resources and a sharp increase in emissions discharges at the early stage of economic growth. However, when economic growth transforms gradually from extensive-scale expansion to intensive growth, the industrial structure will be upgraded and the environmental quality will be improved.

We also investigate the precise channels through which political connections affect firms' pollution discharges. More specifically, our literature review shows that political connections may lead to resource misallocation and unfair implementation of environmental regulation, which would in turn increase firms' pollution discharges. Thus the two channels can be defined as follows.

Resource misallocation (*Misallocation*). Resource misallocation are mainly reflected on investment expansion. The scale and technological effects brought by investment expansion can improve energy efficiency and carbon-reduction technology. However, excessive investment expansion will inevitably increase the demand for energy and resources. The growth rate of net fixed assets is used to measure the effects of investment expansions.

Environmental regulation (*Regulation)*. Pollution treatment expenditure as well as inspection times for pollution discharges are used to measure environmental regulation in the literature (Brunnermeier & Cohen, 2003; Lanoie et al., 2008; Kneller & Manderson, 2012; Brunel & Levinson, 2016). However micro-level data for Chinese firms are either unavailable or incomplete. For this reason, the removal ratio of industrial sulphur dioxide (the ratio of the removal amount of industrial sulphur dioxide to total amount of flue gas discharged) is used as a measure of environmental regulation, which is widely used in the exiting literature (Fu & Li, 2010; Zhang & Chen, 2018; Liao & Shi, 2018; Yang et al., 2018). Therefore, the higher this ratio, the stricter the environmental regulation and control is.

Figure 1 The map of Chinese cities on sulfur dioxide discharge intensity.



Note: The bigger the cycle the more sulfur dioxide pollution in the indicated city.

All variables are as defined in the Appendix A. Table 1 presents the summary statistics of the variables used in the main analyses. Panel A reports summary statistics for major variables discussed in Section 3. There are large variations in SO2 intensity across the sample, indicating that there are significant differences between firms' pollution discharges. Fig. 1 plots the average of SO2 intensity of 233 cities based on 3,988 firm reports in our sample. The figure clearly shows that SO2 intensity in Pearl River Delta, Beijing, Tianjin and Hebei Economic Circle is much higher than that in other regions. Among the 15,238 firm-year observations, 2.66% of local officials share the same city birthplace as one of the top managers of the listed firms located in the officials' jurisdiction, while 2.81% local officials share the same provincial birthplace as the top managers of the listed firms. In contrast, only 2.21% top managers graduated from the same university as the mayors of the districts where the firms are located. The statistics of control variables show that firms are highly levered, with an average asset-to-liability ratio of 4.53%. The average profitability is 43.07%, with a standard deviation of 23.31%. In addition, there is significant difference in firms' scale. It can be found the natural logarithm of total assets in the largest firm is 28.5510, which is about 4.24 times than that in the smallest firm. 28.43% of the sample firms are SOEs, and the remaining 71.57% are non-SOEs. Panel A also shows that the average population density is 579.71 persons per square kilometer in each city. The average ratio of industrial added value in manufacturing to GDP is 0.51, with a standard deviation of 19.87%.

Panel B compares the average pollution intensity of firms with political connections with that of firms without political connections. It can be found that the average pollution intensity of politically connected firms is much higher than that of firms with no political connection. Thus, the univariate analysis demonstrates that political connections are positively associated with firms' pollution intensity.

Table 1 Descriptive statistics of the variables

Panel A: Descriptive statistics for the major variables					
Variables	Observations	Mean	Std. Deviation	Minimum	Maximum
SO2	15,238	0.4618	2.0143	0.0050	14.9859
Political	15,238	0.0266	0.1608	0	1
Political_province	15,238	0.0281	0.1652	0	1
Political_school	15,238	0.0221	0.1471	0	1
Liability	15,238	0.0453	0.1634	4.22e-5	2.6676
Profitability	15,238	0.4307	0.2331	3.56e-5	1.4227
Scale	15,238	22.5217	1.6958	6.7218	28.5510
Ownership	15,238	0.2843	0.4511	0	1
Population	15,238	579.7063	403.3573	16.1664	2648.2560
Pgdp	15,238	1.6061	1.0871	0.1869	13.3341
Manufacturing	15,238	0.5126	0.1987	0.1974	0.8508
Misallocation	15,238	0.1233	0.1897	0	0.8066
Regulation	15,238	0.4943	0.2437	0.0138	0.6990
Panel B: Univariate analysis					
Variables		Observations	Mean	Differences	T-statistic
Political=0		14,832	0.5488	-0.4880***	-4.8133
Political=1		406	1.0368		
Political_province=0		14,811	0.5483	-0.4786***	-4.8387
Political_province=1		427	1.0271		
Political_school=0		14,893	0.3683	-0.1999*	-1.7954
Political_school=1		345	0.5682		

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

4 Empirical results

4.1 Baseline estimates

For most observations in this study, the main explanatory variable, political connections (*Political*), is not time-varying. In such case, if the dummies for firms are included in the regression models and the within estimator is employed, the fixed-effect models cannot compute coefficients for time-invariant variables (Baltagi, 2001; Hsiao, 2003; Wooldridge, 2010). Another drawback of the fixed-effect model which controls for firm individuals is its inefficiency in estimating the effect of variables that have very little within variance. Inefficient estimates not only lead to somewhat higher standard errors but also highly unreliable point estimates and may thus cause wrong inferences in the same way as a biased estimator could (Wooldridge, 2010). Therefore, the inefficiency of the fixed-effect models in estimating time-invariant variables needs to be taken seriously. In light of

this most applied researchers apparently estimated empirical models that include less time-invariant variables by pooled OLS (see for example, Huber & Stephens, 2001; Acemoglu et al., 2003; Heineck & Anger, 2010; Yang, 2011; Jiang et al., 2014). Thus, we employ a pooled ordinary least squares (POLS) model to estimate the effects of political connections on firm's pollution intensity.

Table 2, Column (1) presents our estimation results based on Equation (1). The estimated results show that the coefficient of *Political* is 0.3174 and significant at the 5% levels, indicating that the pollution discharges by politically connected firms are 0.3174 (unit: tons per 10000 RMB) higher than those by firms without political connection. Thus, we can draw the conclusion that political connections are negatively linked with firms' SO2 reduction and hence Hypothesis 1 is confirmed. One possible explanation is that local officials associated with polluters fail to implement or may even distort the environmental policies in order to unduly pursue GDP growth. Another reason is that favourable policies, such as state bank credit and land usage rights, provided for politically connected firms may discourage these firms from adopting advanced technologies which would reduce emissions.

The results in Column (1), Table 2 also demonstrate that the coefficient of *Liability* is negative but fails to pass the significance test at the 10% level, indicating that a rise in liability has no significant effect on firms' pollution discharges. However, firm profitability has a significant and negative influence on pollution discharge, and an increase in firm profitability will decrease its pollution intensity by 0.3812. The coefficients of *Scale* are negative and significant at the 5% levels, implying that firms can obtain positive externalities from economies of scale and reduce their pollution discharges. Additionally, the results show that the coefficients of *Ownership* are negative but fail to pass the 10% significance test, which implies that there is no significant difference in pollution intensity between SOEs and non-SOEs. The reason might be that, although SOEs keep close contact with local governments and have great bargaining power with local environmental authorities to negotiate environmental enforcement (Wang & Jin, 2007), they shoulder more social responsibilities and are inclined to reduce emissions under the pressure of public opinion. So the total environmental effects of SOEs are not significantly different from those of non-SOEs.

We also investigate the effects of macroeconomic variables. Our estimated result in Column (1) shows that both of population density and GDP per capita fails to pass the 10% level of significance test, implying that population density and GDP per capita exerts no remarkable influence on firms' pollution discharges. The estimated results in Table 2 also demonstrate that the coefficients of industrial structure (*Manufacturing*) is negative and significant at the 5% level, indicating that industrial structure is negatively related to firms' pollution discharges. It may be that

many industries in the secondary sector have transformed to high-tech processed and cleaner production, and that the new approach towards industrialization featured by the coordination between economic development and environmental protection has shown positive effects.

Table 2 Regression of political connects on firms' pollution intensity

Variables	Dependent variable: SO2			
	(1)	(2)	(3)	(4)
Constant	2.5002***	2.5110***	2.5904***	2.5207***
	(0.6011)	(0.5917)	(0.5798)	(0.5981)
Political	0.3174**	0.5495**	2.7146***	0.6748*
	(0.1293)	(0.2397)	(0.5330)	(0.3520)
Liability	-0.1673	-0.1657	-0.1632	-0.1729
	(0.1152)	(0.1152)	(0.1158)	(0.1153)
Profitability	-0.3812**	-0.3739**	-0.3910**	-0.3813**
	(0.1839)	(0.1818)	(0.1841)	(0.1834)
Scale	-0.0274**	-0.0266**	-0.0272**	-0.0274**
	(0.0123)	(0.0122)	(0.0123)	(0.0122)
Ownership	-0.0798	-0.0798	-0.0778	-0.0812
	(0.0780)	(0.0777)	(0.0783)	(0.0786)
Population	-0.0002	-0.0003	-0.0002	-0.0002
	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Pgdp	-0.0305	-0.0386	-0.0126	-0.0316
	(0.0706)	(0.0705)	(0.0660)	(0.0691)
Pgdp2	0.0010	0.0014	-0.0001	0.0010
	(0.0044)	(0.0043)	(0.0041)	(0.0043)
Manufacturing	-2.0701**	-2.0027**	-2.1871***	-2.0302**
	(0.8355)	(0.8324)	(0.7920)	(0.8230)
Investment		0.0010***		
		(0.0003)		
Political×Investment		0.6869**		
		(0.2857)		
Regulation		-0.1385*		
		(0.0757)		
Political×Regulation		0.4641**		
		(0.2296)		
Political×dummy_age1			-0.1344***	
			(0.0435)	
Political×dummy_age2			-0.6487**	
			(0.2702)	
Political×dummy_education			-1.2168**	
			(0.5025)	
Political×dummy_tenure			-0.5105*	
			(0.2728)	
Political×dummy_prom1			-0.8160***	
			(0.2426)	
Political×dummy_prom2			-0.4739*	
			(0.2590)	

Variables	Dependent variable: SO2			
	(1)	(2)	(3)	(4)
Political×dummy_NCCPC			-0.1797	
			(0.1415)	
Political×dummy_eastern				-0.7380**
				(0.3741)
Political×dummy_central				-0.2453
				(0.4374)
Political×dummy_municipality				-1.0250*
				(0.5703)
Political×dummy_provincial				-0.7451***
				(0.2737)
Political×dummy_labor				-0.7501*
				(0.4410)
Political×dummy_skill				-0.8326**
				(0.3863)
City dummy	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes
Observations	15,238	15,238	15,238	15,238
R-squared	0.1251	0.1259	0.1280	0.1269

Note: Robust standard errors clustered at city level are shown in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

We also investigate the channels through which political connections influence the environment and present the results in Column (2), Table 2. The estimated results show that the coefficients of political connections are significantly positive, which is consistent with those in baseline regressions. Investment expansion (*Investment)* is introduced into Column (2), Table 2, and the result indicates that the coefficient of *Investment* is significantly positive, demonstrating that investment expansion is counterproductive for emission reduction efforts. The coefficient for the interaction term *Political×Investment* is positive and significant at the 5% levels, indicating that the investment expansion of politically connected firms remarkably raises their pollution discharges. One possible explanation might be that the scale effects of investment expansion decrease gradually under the influence of political connections, and firms need more energy and resources and thus cause more emissions.

In addition, the estimated result in Column (2) demonstrates that the coefficient of *Regulation* is significantly negative, suggesting that environmental regulation can remarkably reduce pollution discharges. However, the coefficient of *Political×Regulation* is positive at the 5% significance level. This result suggests that, as politically connected firms have access to the means to loosen environmental regulation, the effect of environmental regulation is actually diluted significantly. Thus, Hypothesis 2a and Hypothesis 2b are also supported.

4.2 Effects of politicians' heterogeneous background

In this section, we divide our sample into several sub-samples according to the characteristics of officials, and examine potential variation in the relationship between political connections and industrial pollution in different groups. The cross terms of political connections and dummy variables of individual characteristics are incorporated into the models in the following analysis.

According to China's Civil Service Retirement System, the age for promotion opportunity is capped at 55 for prefecture officials and 60 for municipal officials. To reflect the effect of age, the cross terms of political connections and age-specific dummy variables are included in regressions. Specifically, *dummy_age1* takes the value of one if the mayors are between 50 and 55 years and zero otherwise; *dummy_age2* takes the value of one if the mayors are 55 years old or above and zero otherwise. The estimation results in Column (3) of Table 2 indicate the environment is mostly negatively affected by political connections with officials under 50 years old. It is found that the coefficient of *Political*×*dummy_age1* is -0.1344 while the coefficient of *Political*×*dummy_age2* is -0.6487, both of which pass the 5% significance test. Thus, the pollution shelter effects caused by political connections with officials under 50 years old is 0.1344 higher than those associated with officials between 50 and 55 years old while 0.6487 higher than those associated with officials who are 55 years old or above. This may be due to stronger promotion desire from younger officials (Fan et al., 2008; Yao & Zhang, 2012). China's GDP-led promotion system drives these officials to turn a blind eye to environmental standards and pollution discharges. Relatively older officials have less chance for promotions and are probably more concerned with their reputations. They may endeavour to balance economic growth with environmental protection (Li & Zhou, 2005).

Column (3) also considers sub-samples according to officials' educational background. The cross term between political connections and dummy variable capturing education differences is incorporated in the regressions. The *dummy_education* takes the value of one for local officials with bachelor degree or above and zero otherwise. The coefficient of the cross term between political connections and education dummy variables in Column (3) is -1.2168 and significant at the 5% level. This implies that pollution discharges induced by political connections through officials with a bachelor degree or above are 1.2168 lower than those associated with officials who receive high-school education or below. Thus officials with higher education may have better professional skills and knowledge which help them understand the importance of sustainable development.

The tenure of office may affect a local official's willingness to maintain political connections. As the mayors serve no more than two consecutive terms, or ten years in total, we create *dummy_tenure* which is equal to one if the mayors served for five years or below. The empirical

results in Column (3) show that the negative effects of political connections with long-tenure officials are clearly greater than those with short tenure. Specifically, if the officials serve no more than five years, their political connections will be responsible for fewer pollution discharges than long-tenure officials. This result is consistent with Persson and Zhuravskaya (2012), who pointed out that long tenure would help formalize political connections which provide protection for polluting firms.

In addition, how local officials are promoted may reflect their past career and experience (which influence their political ambitions). Thus, we sub-divide the sample according to whether the officials are locally promoted, externally promoted or through parallel move[1]. Therefore two dummy variables are incorporated in the regression to reflect the mayors' turnover type. Specifically, *dummy_prom1* takes the value of one if officials are externally promoted and zero otherwise; *dummy_prom2* takes the value of one if officials belong to the parallel move category and zero otherwise. The estimated results in Column (3) of Table 2 show that the cross term between political connections and dummy_prom1 *(Political×dummy_prom1)* is negative and significant at the 1% level, indicating political connections between officials who are externally promoted have smaller negative effects on the environment. This may be because officials promoted locally are more likely to get support from local elites and form alliances with them, according to Persson and Zhuravskaya (2012). It is much easier for them to form political connections and manipulate environmental regulations. What is noteworthy is that the estimation results in Column (3) reveal that the coefficient of the cross term *(Political×dummy_prom2)* is negative at the 10% significance level, implying that the intensity of pollution discharges induced by political connections with parallel-moved officials tends to be much smaller than that with locally promoted officials. One possible explanation for this finding is that parallel move may reduce the possibility of political connection because the parallel-moved officials need to spend more time to establish new connections with local firms.

With the adjustment of the system assessing officials as well as further development of the anti-corruption campaign after the 18th National Congress of the Communist Party of China, the costs of political connections sharply increased. On the one hand, it is now more difficult for local officials to get private benefits by providing pollution shelter to politically connected firms. On the other hand, the anti-corruption measures have made it difficult for local firms to obtain protection. Therefore, increased costs for political connections inevitably result in remarkable changes in pollution discharges. To capture possible changes before and after the 18th Congress, *dummy_NCCPC* is defined to take the value of one for the post-congress period. Column (3) shows that the coefficient of the cross term between political connections and *dummy_NCCPC* is negative but fails to pass the

[1] Parallel move, or lateral move, refers to the case of a mayor being transferred to another city or a new position at the same rank (Zhou & Dong, 2016). This definition is consistent with that by Li & Zhou (2005) and Wang et al. (2009).

10% significance test, suggesting that the pollution shelter effects caused by political connections do not decrease remarkably after the 18th NCCPC. It is worth noting that any policy has time-lag effects. It can be found if we define *dummy_NCCPC* equals to one when the 18th NCCPC was held after two years or longer. Then the coefficient of the cross term *Political*×*dummy_NCCPC* is negative and significant at the 5% levels. Thus, it can be inferred that firms' incentives to establish political connections are lower along with thoroughly implement of anti-corruption campaign and their capacities to reduce emissions are improved.

4.3 Effects of firm heterogeneity

Significant differences exist among regions with different development conditions, such as government policies and resource endowment. Two dummy variables identifying central and western areas are introduced to examine the location effects on environmental pollution and the estimation results are shown in Column (4) of Table 2. It is noted that politically connected firms in the eastern areas generate the least pollutant emission than those in the central and western areas. This could be because a better legal environment in the eastern regions makes it more difficult for polluting firms to establish political connections with local officials and hence restrains excessive pollution discharges.

The estimation models according to different city hierarchy are presented in Column (4) of Table 2, too. *Dummy_municipality* denotes whether the city is a municipality or not, and *dummy_province* indicates whether the city is a provincial capital or not. The estimated results show that pollution discharges of politically connected firms in prefecture cities are obviously higher than those located in municipalities and provincial capitals. It may be that municipalities and provincial capitals have more preferential policies and financial support from central government and their environmental regulation is more stringent than prefecture cities. Prefecture cities remain relatively underdeveloped in terms of economic and social development. In order to pursue rapid development and more fiscal revenues, local officials may blindly accept high energy-consuming and high-polluting firms, and even act as a protector for polluting firms.

The environmental effects of political connections vary among different industries too. The cross terms of political connections and industrial dummy variables are incorporated in the regressions. The *dummy_labor* and *dummy_skill* variables indicate the firms in labor-intensive and skill-intensive sectors, respectively. The estimated results in Column (4) illustrate that pollution discharges in capital-intensive industries are most negatively affected by political connections, followed by labor-intensive industries. For example, the coefficients of the cross term between political connections and industrial dummies in Column (4) reveal that pollution discharges of politically

connected firm in labor-intensive industries are 0.7501 lower than capital-intensive firms, while pollution discharges of politically connected firm in skill-intensive industries are 0.8326 lower than capital-intensive ones. It may be that firms in capital-intensive industries, also often pollution-intensive ones, benefit more from rent-seeking activities and are more motivated to look for pollution shelter via political connections. By comparison, political connections help skill-intensive firms obtain subsides and preferential policies form the governments. Politically connected firms can adopt clean production technologies to improve energy efficiency and pollution treatment, so their pollution discharges are lower than that capital-intensive and labor-intensive ones.

4.4 Robustness tests

In this section we conduct a set of robustness tests to confirm that our main results hold after alternative specifications are considered.

4.4.1 Alternative measures for political connections and environmental pollution

The first modification considers three optional pollution indices, namely the intensity of industrial COD, dust and waste water emissions. In addition, given that more than one of top managers share the same birthplace as the mayor in whose district the firm is located, we construct a variable *Polcon* and use the number of top managers who are politically connected with the appointed officials to measure the intensity of political connections. Besides, political connections are defined according to the provincial birthplaces as well as education institutions. Moreover, a proxy variable (*PB*) is used to reflect the political background of a firm's top manager who is currently serving or has formerly served in the government, or as a National People's Congress (NPC) delegate or a Chinese People's Political Consultative Conference (CPPCC for short) member. The similar concept was adopted by Fan et al. (2008) and Cai & Sevilir (2012).

The estimated results in Table 3, imply the same set of inferences we obtained from our baseline specification. That is, the estimation results in terms of signs and significance tests are similar to those previously presented and hence robust under alternative indices. In particular, the estimated results in Column (4) of Table 3 show the coefficient of *Polcon* is 0.3197 and significant at the 5% level, which is 0.0023 higher than the coefficient of political connections in our baseline model. This implies that the higher the intensity of political connections, the more pollution discharges the politically connected firms will emit. Additionally, Columns (5)-(6) show that the coefficient of political connections based on education institutions is significant and positive, and its magnitude is much smaller than those in the "birthplace" specifications, confirming that the "same birthplace" relationship plays a more important role in strategic emissions. This reflects Chinese

cultural tradition that connections through hometowns are more prominent in personal networks. Thus political connection, based on "birth place" identity, provides protection for the polluters and causes more serious damage to the environment.

Table 3 Robustness checks: Alternative measures for political connections and pollution intensity

Variables	COD	dust	water	SO2			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-1.3197	-0.0348	-0.2534	2.5009***	2.4997***	2.5635***	2.5299***
	(1.1747)	(0.0932)	(0.1468)	(0.6011)	(0.6008)	(0.5992)	(0.5981)
Political	0.2881**	0.0054	0.3039**				
	(0.1419)	(0.0093)	(0.1397)				
Polcon				0.3197**			
				(0.1268)			
Political_province					0.3271***		
					(0.1191)		
Political_school						0.2566***	
						(0.0708)	
PB							0.1034*
							(0.0527)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,951	13,256	14,833	15,238	15,238	15,238	15,238
R-squared	0.1789	0.1198	0.1910	0.1250	0.1251	0.1248	0.1249

Note: The dependent variables are listed in the first row. Political connections in Column (5) are constructed according to the provincial birthplace and those in Column (6) according to education institutions. Robust standard errors clustered at city level are shown in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

4.4.2 The effect of outliers

As for the second modification, all continuous variables are winsorized at the top and bottom one percent to remove the effect of outliers according to Crinò and Ogliari (2017). Besides, SO2 intensity is censored at 1% in each tail to adjust the abnormal values. The results listed in Columns (1)-(2), Table 4 suggests the same set of inferences as we obtained from our baseline specification. That is, the estimation results in terms of the sign and significance are similar to those previously presented.

Table 4 Robustness checks: Removing the effect of outliers and endogeneity test

Variables	Dependent variable: SO2				
	(1)	(2)	(3)	(4)	(5)
Constant	2.8701***	2.2376***	2.5405***	2.5042***	2.3784***
	(0.6272)	(0.5020)	(0.6690)	(0.6012)	(0.5256)
Political	0.3116**	0.3055***	0.3167**		
	(0.1240)	(0.1105)	(0.1287)		
Match				0.3155***	
				(0.1295)	
Political_IV					0.1994*
					(0.1185)
imr			-0.0253		
			(0.1666)		
Control variables	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Observations	15,238	15,085	15,238	15,235	15,238
R-squared	0.1284	0.1162	0.1251	0.1250	——

Note: All continuous variables are winsorized at the top and bottom one percent in Column (1), and SO2 intensity are censored at 1% in each tail in Column (2). Column (3) presents the results for the endogeneity test using Heckman's two-stage procedure; Column (4) presents the results for the endogeneity test using PSM procedure; Column (5) presents the results for the endogeneity test using two-stage least square regression. Robust standard errors clustered at city level are shown in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

4.4.3 Endogeneity tests

The possible existence of endogeneity may be problematic. First, the causal relationship between political connections and industrial pollution may be bidirectional. In comparison with developed countries, the environmental regulation in China is relatively loose (Zeng et al., 2012; Wang, 2013). Thus, polluting firms are very keen to obtain protection by searching for political resources and government support (Rodrigue et al., 2013). In this case, an increase in pollution discharges may lead to more political connections. Second, although we have controlled for other important variables influencing industrial discharges, we cannot rule out the endogeneity issue caused by omitted variables which may be related to political connections (Chen et al., 2013). According to Lin et al. (2016) and Su et al. (2018), we adopt three different approaches, namely Heckman's two-stage procedure, propensity score matching (PSM) method as well as two-stage least square regression to deal with endogeneity.

The two-stage procedure of Heckman (1979) involves the estimation of a probit model of political connections, the inverse Mills ratio (imr for short) and the inclusion of imr in the pollution equations as a control variable. In the first stage, we perform a probit regression with *Political* as

the dependent variable. According to Boubakri et al. (2008) and Chen et al. (2011), GDP per capita (*Pgdp*) and the absolute value of fiscal deficit (*Deficit*) are incoprorated into the probit model as the city-level control variables. We also control for firm characteristics (such as liability, profitability, scale and ownership) to assess the possible motives of firms in building political connections. The resulting inverse Mills ratio (imr) is incorporated into the second-stage regression to correct any potential bias. Column (3) of Table 4 presents the estimated results of the second-stage regression which show that the coefficient of political connections is still positive and significant at 5%. Thus, the main conclusions still hold, namely, political connections increase firms' pollution discharges.

Moreover, we use a PSM method to address self-selection bias. The key to propensity score matching is to identify treatment and control groups. The treatment group consists of politically connected firms (*Political*=1) and other firms as the control group (*Political*=0). Our control sample is selected by nearest neighboring logit propensity score one-to-one matching strategy with a set of macro-level and firm-level characteristics including *Pgdp*, *Deficit, Liability*, *Profitability*, *Scale* and *Ownership.* Hence, each firm with no political connection is matched with a politically connected firm with the closest propensity score without replacement on the basis of these variables. We calculate the difference and its t-statistic between the treatment and control groups in terms of each of the above variables, and find that the biases of all variables are less than 10% after matching, and t-statistics do not reject the null hypothesis that there are no differences between treatment and control groups after matching. Then the variable *Match* is an indicator variable which is equal to one if the firm is in the treatment group and zero if it is in the control group. The coefficient of *Match* in Column (4) of Table 4 is positive and significant at the 1% level, indicating that the pollution discharges by politically connected firms are higher than those by firms with no political connection.

To address the endogenous problems resulting from omitted variables, we estimate a two-stage least square regression using employment rate (*Employment*) of the city where the firm is located as the instrument for political connections. The reason for this instrumental variable selection is that political connections may be more common in areas where high employment rates are maintained while there is no evidence that regional employment rates directly affect firms' pollution discharges (Chen et al., 2011; Su et al., 2018). We firstly regress the indicator variable for political connections on the instrumental variable and other control variables. By doing so, we can compute a residual *Political* variables (called *Political_IV*). Then we conduct the second-stage regression using *Political_IV* as the measure for political connections. As shown in Column (5) of Table 4, the coefficient of *Political_IV* is positive and significant at the 10% level, indicating that our main findings still hold after potential endogenous problems are considered by using an instrumental approach. Following Kleibergen & Paap (2006), we perform an underidentification test and weak-

identification test to verify the validity of instrumental variables. LM test is 13.561 and rejects underidentification at the 1% significance level, while Wald F test is 18.544 and rejects the null hypothesis that our instruments are weak at the 10% levels. Thus, our instrumental variables are reasonable. Overall, the conclusion that political connections significantly increase firms' pollution discharges is still valid after the consideration of endogeneity problems by using various methods.

5 Conclusions and remarks

The frequent haze episodes and high pollution emissions have become severe issues faced by the Chinese policy-makers. Though there are studies in this field, they cannot explain why environmental enforcement is even laxer as emission reduction targets proposed by central and local governments become more stringent. By merging datasets of Chinese officials and micro-firms covering the period of 2007-2015, we analyse how political connections between politicians and top managers influence pollution discharges. The empirical results show that political connections are the institutional origin that causes firms to adopt strategic pollution discharges. Political connections significantly increase firms' pollution discharges, and this result is still valid after a series of robustness checks and consideration of endogeneity problems by using different methods.

We also pay special attention to the role of individual characteristics in moderating the relationship between political connections and pollution discharges. The estimation results by subsamples reveal that local officials with less education, a younger age, longer tenure and local promotion are more likely to establish political connections, which results in regulatory violation and excessive emissions. Empirical results also show that the pollution shelter effects caused by political connections are more obvious in central and western regions, prefecture cities and capital-intensive industries.

Our findings not only provide empirical evidence for understanding the relationship between political connections and industrial pollution, but also have important policy implications for cadre management and firm governance reforms. The central government should formulate reasonable incentive mechanisms to properly handle the relationship between economic growth and environmental protection. Apart from the green GDP accounting system and multiple standards in political promotion, sound accountability and supervision mechanisms should be established in order to reduce the possibility of collusion between local officials and top managers of polluting firms. Moreover, local governments should make greater effort to transform from their traditional role of business control and intervention to service-provision and regulatory support so that environmental policies can be effectively implemented. As for firm governance, the environmental information

disclosure system of listed companies should be strengthened and corporate environmental responsibilities should be strictly monitored.

While offering a new perspective on identifying the environmental effects of political connections, our study has limitations that represent opportunities for further research. In particular, our empirical results reveal that politically connected firms produce more pollution than their counterparts, but it would be more compelling to investigate whether politically unconnected firms turn to emit more pollution discharges after they are able to form political connections with local politicians, or how firms' pollution discharges change after they lose political connections. This is a potential topic for follow-up research when relevant data are available. In addition, although our study identifies the environmental effects of political connections and uncovers their variation across different regions, industries and politicians, we cannot distinguish different roles of top managers in forming political connections.

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Appendices

Appendix A Variable definitions

Variables	Definition
SO2	Amount of discharged SO2(ton)/sales(10 thousand RMB)
Political	A dummy variable, equals to one if the local official has the same birthplace as one of the top managers of a listed firm located in the official's jurisdiction and zero otherwise
Political_province	A dummy variable, equals to one if the local official shares the same birthplace as the top manager at the provincial level and zero otherwise
Political_school	A dummy variable, equals to one if the top manager of a listed firm graduated from the same university as the mayor in whose district the firm is located
Liability	The ratio of total debts over total assets
Profitability	The ratio of net profits over net assets
Scale	The natural logarithm of total assets
Ownership	A dummy variable, equals to one if the firm whose ultimate controllers are the state and zero otherwise
Population	Population per land area (square kilometer) in each city
Pgdp	GDP per capital in each city (10000 RMB)
Manufacturing	The ratio of industrial added value in manufacturing to GDP
Misallocation	The growth rate of net fixed assets
Regulation	The removal of industrial sulphur dioxide /(the removal of industrial SO2+the amount of industrial SO2 discharged) in each city

Appendix B Endogeneity test on mechanisms of political connections influencing the environment

Variables	Dependent variable: SO2		
	(1)	(2)	(3)
Constant	2.5586***	2.5594***	2.1863***
	(0.6622)	(0.6624)	(0.5355)
Political	0.3489**		
	(0.1392)		
Investment	0.0009****	0.0009****	0.0014**
	(0.0004)	(0.0004)	(0.0006)
Regulation	-0.1085	-0.1367*	-0.1452*
	(0.0656)	(0.0762)	(0.0823)
Political×Investment	0.6873**		
	(0.2858)		
Political×Regulation	0.4648*		
	(0.2403)		
Match		0.2254**	
		(0.0902)	
Match×Investment		0.6892**	
		(0.2858)	
Match×Regulation		0.4178**	
		(0.1908)	
Political_IV			0.2689**
			(0.1243)
Political_IV×Investment			0.4746*
			(0.2690)
Political_IV×Regulation			0.3101
			(0.2048)
imr	-0.0299		
	(0.1669)		
Control variables	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes
City dummy	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes
Observations	15,238	15,235	15,238
R-squared	0.1259	0.1258	——

Note: Column (1) presents the results for the endogeneity test using Heckman's two-stage procedure; Column (2) presents the results for the endogeneity test using PSM procedure; Column (3) presents the results for the endogeneity test using two-stage least square regression. Robust standard errors clustered at city level are shown in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

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