Race to Safety: Political Competition, Neighborhood Effects, and Coal Mine Deaths in China

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Abstract

When political agents are subject to centralized performance evaluation, their efforts and performances tend to be correlated with one another in the "neighborhood". Using quarterly data from prefecture-level cities in China, this paper finds evidence of positive neighborhood effects on coal mine deaths: the number of accidental deaths in a city is positively associated with those in its political neighbors. The neighborhood effects are confined by provincial borders, but do not diminish as the geographic scope of the neighborhood increases. Moreover, the effects are amplified by regulatory reforms and political cycles that increase the salience of coal mine safety. The findings of neighborhood effects on coal mine deaths are consistent with the logic of relative performance evaluation (RPE) as a mechanism for shaping policy outcomes.

Keywords: Neighborhood Effect, Coal Mine Death, Relative Performance Evaluation

JEL: D73, H77, L51

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Highlights

- We study the pattern of neighborhood effects on coal mine deaths in China.
- The level of deaths are positively correlated among cities in the same province.
- The neighborhood effects do not exist beyond provincial borders.
- The effects are stronger when coal mine safety gained a higher degree of salience.
- Relative performance evaluation seems a mechanism driving the effects.

1 Introduction

Performance comparison across jurisdictions constitutes an important component of political incentives in multi-agent organizations. Political principals may use incentive schemes, such as relative performance evaluation (RPE) and tournament competition, to provide incentives for bureaucratic agents and enhance their performance (Holmstrom, 1982; Lazear and Rosen, 1981; Shleifer, 1985). In electoral contexts, voters often compare the performance in their own jurisdictions with those in neighboring districts to assess the ability of incumbent politicians, forcing them into a de facto yardstick competition (Besley and Case, 1995). In either circumstance, agents are incentivized by inter-jurisdictional competition, and a positive performance correlation often assumes among jurisdictions. The existing literature, however, mostly focuses on competition over primary policy issues such as economic growth or fiscal budget. It is rarely studied whether similar logic extends to the incentive and efforts for second-dimensional policy issues.

This paper intends to study the incentives of local leaders to address a second-dimensional policy by examining the neighborhood effects in coal mine deaths in China. We estimate the (positive) correlation in coal mine deaths among prefecture-level cities within the same province, and interpret this neighborhood effect as stemming non-trivially from the mechanism of RPE for city leaders. Comparing with other channels proposed in the literature for explaining neighborhood effects, such as learning and information spillover (Bloom, Schankerman, and Van Reenen, 2013; Callander and Harstad, 2015; Case, Rosen, and Hines, 1993), promotion competition based on RPE is arguably a more relevant mechanism responsible for the neighborhood effects in China. Local officials are evaluated by their superiors, and city leaders compete with each other for positions at higher levels (Li and Zhou, 2005; Xu, 2011; Yao and Zhang, 2015). To incentivize local leaders on a specific policy, the provincial superior may calibrate the incentive scheme for that policy to induce local leaders' compliance and responsiveness. In turn, neighborhood effects tend to occur along highly salient policies in the eyes of the principal.

We focus on coal mine deaths to examine the political economy of neighborhood effects for two reasons. First, coal and coal mine safety are issues of high salience for the Chinese central government. On economic importance, the coal industry provides over 70 percent of China's domestic energy consumption and a considerable share of local revenue (Wang, 2006). Hence, regulators often have to confront the calculation of the economic costs associated with stringent safety regulations. On political importance, coal mine safety was a constantly embarrassing issue for the Chinese government over the recent decades, with a fatality rate 11 times that of Russia, 15 times that of India, and 140 times that of the United States as of 2000 (Wright, 2004). Surging coal mine deaths posed a threat to social stability, which is a key concern of the ruling Chinese Communist Party (CCP).[1] In reaction to public infuriation over coal mine deaths, the central government implemented comprehensive regulatory overhauls in an attempt to make substantial progress on coal mine safety. And they did. From theoretical and policy perspectives, it is interesting to study how the interventions initiated by the central government worked in shaping the incentives of local governments.

Second, coal mine safety is an issue on which the performance of local governments can be evaluated through a tangible measure, the number of coal mine deaths; and coal mine safety has gained increasing weight in the RPE for local leaders after 2000 along with the centralized reforms. The State Council implements strict sanctions on local officials for severe coal accidents occurring in their jurisdictions. These reforms were likely to impose a "mandate" on local leaders to improve on coal mine safety. Similar to the case of GDP growth, the RPE on coal mine safety is one of the main mechanisms leading to strategic interactions among coal-producing cities in the same province. Intuitively, when a city's neighbors make substantial progress on the reduction in coal mine deaths, the improvement in a city's own safety becomes more urgent. Falling behind on safety is likely to dampen the reputation of local leaders, hindering their probability of promotion. In turn, the logic of RPE is consistent with the positive correlations in coal mine deaths among coal-producing cities that are regulated and evaluated by the same provincial government.[2] Our empirical exercises hinge on this hypothesis.

The empirical analyses rely on the quarterly data on coal mine deaths in 163 major coal-producing cities from 2001 to 2011. In China, performance evaluation on coal mine safety is conducted both quarterly and yearly. Although the yearly evaluation constitutes an important time-dimension of promotion competition for local leaders, competition

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[1] According to the "Comprehensive Evaluation Methods for Local Party and Government Leaders." formally issued by the CCP's Organization Department in 2009, the maintenance of social stability is one of the 13 key issues for the performance evaluation on chief leaders and one of the 8 key issues for evaluating local governments as a whole. (`http://www.hnscdj.gov.cn/show.aspx?id=3642&cid=31`, accessed by June 30, 2017).

[2] There are qualitative evidence on the maintenance of social order and work safety as tangible measures in the RPE for local governments. For example, Cai (2012) documents that social and workplace safety constitute 10 percent of total scores in the performance evaluations of local leaders in a prefecture-level city in Guangdong province in 2009.

among cities occurs incessantly throughout the year. In most policy domains, the yearly evaluation is based on cumulative measures of RPE which is conducted in every quarter. In addition, promotions and bureaucratic transfers may occur in any quarter throughout the year.[3] Estimating the neighborhood effects with quarterly data grants us the flexibility to examine the dynamic incentives of local officials largely in line with the logic of RPE on policies.

The main challenge to identification of the neighborhood effect is simultaneity bias. Because cities in the same province may have exerted mutual influences on safety, linear estimates of spatial autoregressive model on inter-governmental interactions are biased due to the "reflection problem"(Manski, 1993). To deal with this problem, we first adopt the quasi-maximum likelihood (QML) estimation proposed by Lee and Yu (2010) to solve the endogeneity problem in a spatial autoregressive (SAR) model. As an alternative estimation strategy, we follow the literature on social interactions to adopt the one-period lag of neighbors' deaths as a proxy and estimate a dynamic model (Aizer and Currie, 2004; Fredriksson and Millimet, 2002; Munshi, 2004). In addition, although our primary interest in the neighborhood effect focuses on the incentive role of RPE, it is quite plausible that cities react to instructions of provincial and central governments to overhaul the workplace safety regulation. Hence, the positive correlation on the coal mine deaths may stem from contextual interactions (Manski, 2000). To alleviate the possibility that our estimates for the neighborhood effects are inflated by the contextual interactions, we include city fixed effects, year-quarter fixed effects, provincial-specific time trends, and provincial-specific effects of political cycles, to control for cities' common reactions to external shocks.

The QML estimation and linear estimations yield qualitatively similar results that the level of coal mine deaths in a city is positively associated with the average level of deaths in its political neighbors, which are defined as other coal-producing cities in the same province. However, in addition to strategic interactions among local governments in line with the logic of RPE, the neighborhood effect in coal mine deaths may be caused by other factors, such as inter-regional market interactions, information spillovers, or Tieboutian competition (Acemoglu, Garcia-Jimeno, and Robinson, 2015; Bloom, Schankerman, and Van Reenen, 2013; Lyytikäinen, 2012). To disentangle the neighborhood effect due to

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[3] To give one example, there were 55 political turnovers among the 60 political turnovers for provincial governors and party secretaries who were in office right after the 18th National Congress of CCP in 2012. Of those, 21 changes occurred in the first quarter, 13 occurred in the second quarter, 8 occurred in the third quarter, and 13 occurred in the fourth quarter.

RPE and other channels, we compare estimates considering geographical and political neighbors, as well as economically comparable cities in the same province. The results are twofold. First, the effect is invariant to the size of the neighborhood for cities in the province, but it is nonexistent for cities that are geographically proximate but located in different provinces. Second, within a province, neighborhood effects are stronger among economic neighbors, cities whose per capita GDPs are close to each other; and there are no such effects among economically proximate cities across provinces. These empirical patterns on the neighborhood effect are consistent with the logic of RPE, but they provide no support for the premise that the effect stems from market interactions.

We explore higher-order time lags of neighbors' average deaths as an explanatory variable to further study the dynamic neighborhood effects. Within the same year, the neighborhood effect persists for as long as three quarters. By contrast, the cross-year dynamic neighborhood effect persists relatively shorter, and its magnitude is smaller. The patterns of dynamic neighborhood effects based on quarterly data are consistent with the estimates using yearly data, which suggests that spatial interactions on coal mine deaths mainly occur in the same year. The relevance of neighborhood effects within the same year implies that promotion competition is a key underlying mechanism driving the spatial correlation, as quarter and year are the main time horizons of the RPE for local officials. The effects are unlikely to be driven only by common shocks in the market, as those shocks are not restricted within the same year.

Recent research on the quality of official data in China raises concerns about report manipulation (Fisman and Wang, 2016; Wallace, 2016). Neighborhood effects may result from systematic underreporting on deaths, rather than real improvement in safety. We test whether the neighborhood effects could be primarily driven by manipulation in a cluster of cities. The empirical strategies in the two tests respectively consider increasing the prevalence of manipulation in the fourth quarter, and using the distance from cities to provincial capitals as a mediation of neighborhood effects. In contrast to what the logic of report manipulation would dictate, the results suggest that the estimates are unlikely to be due to strategic underreporting even though manipulation may nevertheless exist.

Analyzing coal mine safety through the lens of neighborhood effects sheds lights on the role of promotion competition in shaping the performance on second-dimensional issues. One intuition based on the logic of RPE is that cities respond more acutely to neighbors' performance on issues that are of higher salience in the RPE. We explore the variation in the salience of coal mine safety at the national and city levels to test this implication. The analysis finds that neighborhood effects became stronger (1) when the central government imposed more stringent rules of bureaucratic sanctions for safety negligence after 2005; and (2) when the date was moving toward the National Congress of CCP. Furthermore, cities lagging behind on coal mine safety react more strongly to neighbors' safety performance, while city leaders with a local birthplace are associated with weaker neighborhood effects on coal mine deaths. Taken together, the results lend supports for the incentive roles of RPE in shaping the performance of local governments: neighborhood effects seem to be more acute under the circumstance where coal mine safety matters more for the evaluation of local leaders.

This paper is related to several strands of literature. First, our focus is closely related to the empirical research on political selection and government performance in China (Chen and Kung, 2016; Li and Zhou, 2005; Lü and Landry, 2014; Yu, Zhou, and Zhu, 2016). In particular, Yu, Zhou, and Zhu (2016) employ spatial econometric models to estimate the strategic competition among city governments for GDP growth, and find positive interaction among cities with similar economic ranks. Our paper follows this path to study spatial interaction in government performance, yet we focus on coal mine safety, an important second-dimensional issue that is normally underappreciated in literature as a determinant of officials' career advancement. Our findings complement the existing research by showing that competition may help address these issues, as long as they are taken seriously in performance evaluation. The logic should extend more generally to other "second-dimensional" issues such as environmental regulation and food safety (Fredriksson and Millimet, 2002; List, Strum, and Sturm, 2006; Markusen, Morey, and Olewiler, 1995).

The present paper adds to a growing body of literature on the political economy of regulation in China. Jia and Nie (2015) document that decentralization of control rights in state-owned mining companies has a detrimental impact on safety, due to a business-government collusion. Nie, Jiang, and Wang (2013) find that provincial death rates in the coal mining industry decreased significantly prior to the "two sessions" of provincial political cycles. Fisman and Wang (2016) study the incentive distortions caused by the implementation of "death ceilings," a threshold of deaths related to promotion and sanction. This research concentrates on the direct responses of agents to the principal. In this regard, our analyses on horizontal interactions among cities provide a refined account for how regulatory reforms may work in an essentially centralized political system.

Finally, our paper speaks to a large literature on intergovernmental interactions in the context of electoral accountability. Democratically elected politicians need to keep pace with their neighbors over taxation and welfare provisions when voters use policies and performance in neighboring regions as a benchmark to determine whether politicians have delivered satisfactory performance (Besley and Case, 1995; Bordignon, Cerniglia, and Revelli, 2003; Figlio, Kolpin, and Reid, 1999). The literature documents a mediating role of centralization in shaping inter-jurisdictional competition (Revelli, 2003, 2006). By contrast, the present paper finds that the neighborhood effects may intensify along with centralization, which we attribute to the centralized personnel control in China.

The remainder of the paper is organized as follows. Section 2 provides a sketch of the institutional background on personnel control and regulation of coal mine safety in China, and introduces the theoretical intuitions linking promotion competition and neighborhood effects on coal mine safety. Section 3 describes the data. Section 4 discusses the identification strategy. Section 5 reports the empirical results. Section 6 concludes the paper.

2 Institutional Background

This section provides the institutional background for the regulation of coal mine safety in China. We first introduce the implications of RPE for the incentive of local leaders. We then describe important regulatory reforms on coal mine safety in recent decades. Finally, we discuss the theoretical intuitions linking neighborhood effects and the overall improvement in coal mine safety.

2.1 Incentive of Local Leaders

The administrative system in China is organized as a hierarchy of subnational units that compete economically and politically with each other. Regional governments enjoy substantial discretionary powers in economic affairs, including the power to determine the composition of local expenditures, invest in public goods, manage local state-owned enterprises, and grant tax exemptions to investors. Meanwhile, local leaders compete for career advancement, and their promotions hinge on performance evaluations conducted by their superiors (Xu, 2011). Competition among local leaders in the same political jurisdiction implies a convergence of policies and performance, particularly on issues that are salient in the RPE.

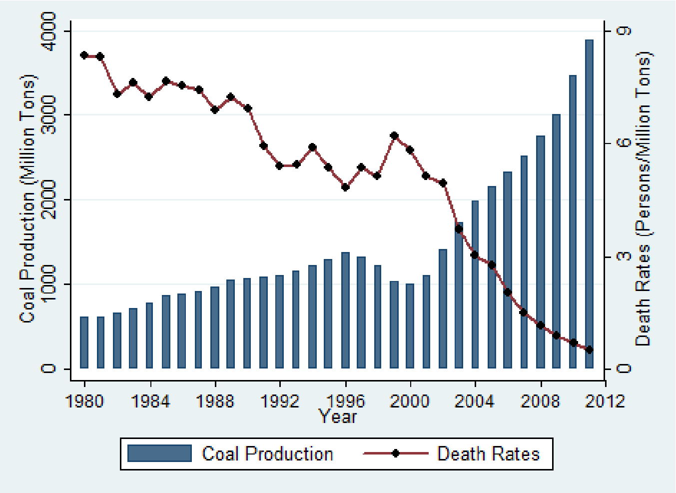
In the Chinese context of the post-Mao era, economic growth has turned into a primary issue for the ruling party's political survival, famously following the political slogan that "Development is the hard principle." (Gallagher, 2002; Shirk, 1993). Empirical evidence attests to the importance of economic growth as an important determinant of promotion for local leaders (Li and Zhou, 2005; Yao and Zhang, 2015). Moreover, a recently growing body of literature shows that regional governments strategically allocate efforts to enhance GDP growth and fiscal performance, reflecting potential competition from their political neighbors (Lü and Landry, 2014; Yu, Zhou, and Zhu, 2016). However, there has been little research on whether second-dimensional issues that do not immediately translate into growth have a bite in driving the incentive of local leaders.

The number of coal mine deaths aroused enormous public attention in the early 2000s. The coal mining industry accounted for less than 4 percent of the industrial workforce, yet it contributed to over 45 percent of industrial fatalities. As Figure 1 shows, the total number of coal mine deaths peaked in the 1990s and remained at a historically high level in the 2000s. But starting in 2003, there has been a fast and steady decline over time in the number of coal mine deaths. Moreover, the death rate decreased considerably in this period, suggesting that the declines in total deaths were not simply due to cutdowns in production capacity. We argue that the salience of coal mine accidents in the RPE is important for understanding the incentive of local leaders to improve the safety.

2.2 Regulation of Coal Mine Safety

Two conditions are necessary for local governments to take coal mine safety seriously. First, there needs to be a tangible and reliable measure of safety performance for the provincial superior to conduct RPE. Second, the superior should pay enough attention to the safety issue in designing the promotion (and sanction) scheme so as to provide career-concern incentives for local leaders to comply with the goal of the superior. These conditions are not always satisfied. Regulation of the coal mine safety was comparatively decentralized before the establishment of the State Administration of Coal Mine Safety in 1999. The Ministry of Coal Industry, the nominal regulator of the coal mine industry at the state level, was a marginalized and unstable bureaucratic branch, subject to frequent restructuring and downgrading, and was eventually abolished along with administrative

Figure 1: Coal Production and Safety in China: 1980-2011



Notes: This figure presents total coal mine deaths and total coal production per year. The data are obtained from the *Chinese Yearbook of Workplace Safety.*

decentralization by the State Council in 1998.[4] In turn, the focus on safety supervision did not penetrate down to the local level, and systematic performance evaluations of coal mine safety were infeasible, due to the lack of regulatory capacity.

Without strong regulatory power, the jurisdiction of regulating small and medium-sized coal mines were delegated to local governments. Local governments were responsible for supervising mining operations and enforcing safety regulations, and they were legal owners of most township-and-village (TVE) coal mines. The incentive to enhance coal mine safety, however, was often compromised by the exclusive focus of local governments on growth and revenue. Under the decentralized fiscal contract system between 1978 and 1993, local governments became a residual claimant of public revenues (Jin, Qian, and Weingast, 2005; Shen, Jin, and Zou, 2012). Improvement in coal mine safety involves substantial inputs, including safety supervision, subsidies for technology upgrading, and shutting-down of unsafe mines. The implementation of these policies tends to hinder economic gains in growth or personal rents (Wright, 2004; Wang, 2006).

To address the safety problems, the central government adopted an array of reforms to overhaul the regulatory system. The first set of reforms aimed at empowering regulators at each administrative level. Between 1999 and 2003, the State Administration of Coal Mine

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[4] The Ministry of Coal was first established in 1955 as a typical U-formed organization specializing in managing the coal industry. It was merged with the Ministry of Petroleum and Ministry of Chemical Industry in 1970, then granted independence in 1975, abolished in 1988, rebuilt in 1993, and again abolished in 1998.

Safety (SACMS) was a sub-ministerial division supervised by the National Commission of Commerce. The State Council rebuilt the SACMS into the State Administration of Workplace Safety (SAWS) in 2003, and upgraded its rank from sub-ministerial to ministerial level in 2005. The vertically administrated system improves the transparency of performance evaluation of coal mine safety, and renders it more difficult for local governments and coal mining companies to collude on safety regulation.

The second set of reforms targeted the incentive of local governments. The central government reasserted a clear position on bureaucratic sanctions in response to severe accidents.[5] Routinized performance evaluation on safety became increasingly important in shaping political competition. Subnational governments are required to submit reports on workplace safety to provincial regulators on a quarterly base. A quarterly meeting is institutionalized to help implement the enforcement of safety regulation.[6]

2.3 Promotion Competition and Neighborhood Effects

We attribute the improvement in coal mine safety to changing incentives of local governments. Safety tends to be salient for local leaders when it is related to their career advancements. Regions lagging behind on safety would then have stronger incentives to curb disasters by all means. This implies a positive neighborhood effect under which regions are mutually pressured by their political neighbors in a "race to safety." For example, it is reported that Si'chuan province was embarrassed by its "top ranking" on the number of existing small mines (which are typically unsafe), when it was dwarfed by substantial progress in Shan'xi province on coal mine closure. The provincial minister of workplace safety in Si'chuan alluded to the campaign of cutting coal mine deaths as an "unfolding competition on workplace safety." In response to that, the provincial bureau of workplace safety in Si'chuan set specific safety targets and technological standards for all cities within the province.[7]

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[5] *The Workplace Safety Law* passed in 2002 specifies legal liabilities of local regulatory agencies and government officials for negligence in workplace disasters. In 2005, the State Council adopted *the Special Regulations for Preempting Coal Mine Disasters*, instituting rules of sanction for county and township government officials. *The Administrative Accountability for Severe Safety Disasters* passed by the State Council in the same month specifies the responsibility of provincial government officials. Due to the implementation of the accountability system, the governor of Shan'xi province was forced to step down following a disaster killing 277 lives in 2008.

[6] Requirements to Enhance Workplace Safety by the State Council. (Guowuyuan Guanyu Jinyibu Jiaqiang Anquan Shengchan Gongzuo de Jueding.) Available at: www.china.com.cn/chinese/PI-c/483862.htm, accessed May 30, 2016.

[7] "Si'chuan faces particular pressure following big cut-downs of coal mines in Shan'xi," article in *China Energy News*, March 17, 2010.

In principle, the patterns of neighborhood effects should exist in regard to other kinds of accidental deaths. However, the magnitude of neighborhood effects on a specific policy depends on its significance in performance evaluation. The importance of coal mine safety compared with other workplace accidents is evident in light of the establishment of the State Administration of Coal Mine Safety in 2003, which functioned as a sub-ministerial regulatory agency under SAWS. There is no counterpart regulatory agency for other sectors. Moreover, as the left panel of Figure 2 demonstrates, coal mine accidents received more intense media coverage than other domains of workplace safety did, presumably because of the prohibitively high numbers of casualities in severe accidents. Ubiquitous coal mine accidents were in dissonance with “Harmonious Society,” an idea championed by President Hu Jintao and Premier Wen Jiabao in the 2000s. The intense media coverage of coal mine safety reflects its importance in the domain of workplace safety regulation.[8]

In the appendix, we provide a heuristic model to clarify the theoretical intuition linking political competition and neighborhood effects on coal mine deaths. The incentive of local governments stems from the political gain from enhancing coal mine safety and the benefits of condoning low-safety conditions. The model predicts that the RPE effect, as manifested by a positive spatial correlation on coal mine deaths, tends to dominate in the neighborhood effects when the principal attaches enough of importance to coal mine safety in the RPE. Moreover, the positive neighborhood effect is stronger when the agent cares enough about the political gain associated with an improved ranking on safety. Consequently, the model suggests that stronger interaction among coal-producing cities is associated with an overall improvement in coal mine safety at the national level in recent years. This implication is consistent with the right panel of Figure 2, which shows faster declines in total coal mine deaths, but not for other types of accidental deaths in recent years. Therefore, we concentrate on the neighborhood effect in coal mine deaths as an indicator of political incentive.

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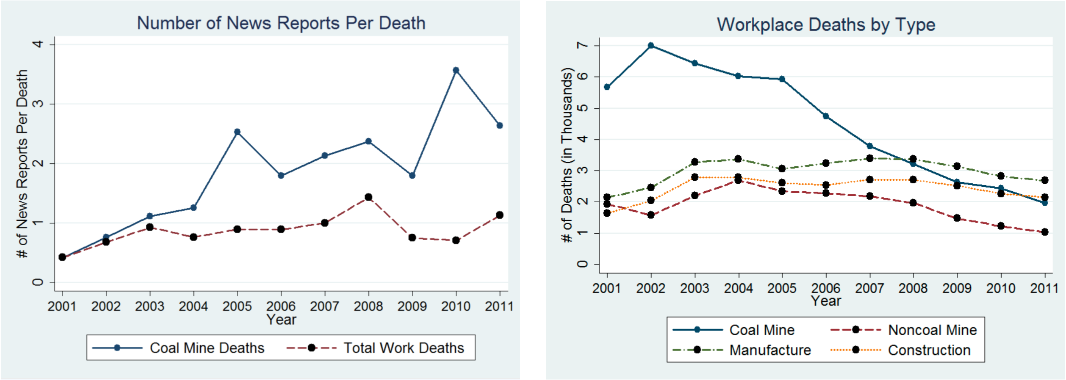
[8] Even official newspapers backfired against governmental negligence potentially leading to the accidents. In response to a mass accident killing more than 140 workers in Henan province in 2004, *Legal Daily* (Fazhi Ribao), a national newspaper supervised by the Ministry of Justice, questioned whether the accident was due to natural causes or was indeed a human-made disaster. “An reflection on the coal mine disaster in Daping, Henan province: Hundreds of lives crying to Heaven.” (Fansi Henan Xinmi Daping Kuangnan: Baitiao Shengming Wen Cangtian.) http://news.china.com/zh_cn/focus/kuangnan/11024884/20041023/11929268.html, accessed June 14, 2017. *People's Daily* called for resignation of subnational leaders after a severe disaster in Hongdong, Shanxi province in 2007. “Should local officials resign for the recent coal mine disaster in Hongdong?” (Shanxi Hongdong Teda Kuangnan: Shifou You Guanyuan Yinggai Yinjiu Cizhi?) http://www.people/com.cn/GB/32306/33232/6633659.html, accessed May 30, 2016.

Figure 2: Salience of Coal Mine Safety



Notes: The left panel reports the number of newspaper reports on workplace accidents per coal mine worker death and overall workplace deaths. The universe of reports includes all publicly circulated newspapers in the online database WiseNews (wisenews.wisers.net). The right panel reports the number of annual total deaths in coal mining and other sectors. The data are obtained from the *Chinese Yearbook of Workplace Safety*.

3 Data

3.1 Sample Selection

We obtain information on coal mine deaths from the online database of workplace disasters at the website of the State Administration of Workplace Safety (SAWS).[9] Local regulatory bureaus are required by law to report information on each disaster, including time, location, technical causes, and number of deaths, to SAWS. We aggregate the reported information on coal mine deaths to the city-year-quarter level. For the purpose of examining neighborhood effects, we include in the sample the 163 main coal-producing in 20 provinces. The coal-producing cities included in the sample account for over 97 percent of the total production in 2010.

The sample selection takes two steps. First, we pick out coal producing provinces with annual production greater than 10 million tons. In this step, we exclude six provinces with zero or very small volume of coal production (Guangdong, Guangxi, Hainan, Qinghai, Xizang, and Zhejiang).[10] We also drop four direct-controlled municipalities (Beijing, Shanghai, Tianjin, and Choingqing), because these cities have higher administrative ranks

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[9] `http://media.chinasafety.gov.cn:8090/iSystem/shigumain.jsp`

[10] Very few cities in these six provinces produced coal during the period we examine. Coal production in Guangdong, Guangxi, Qinghai, and Zhejiang has been decreasing over time, and by 2006 most cities in these provinces stopped producing any coal. Hainan and Xizang did not produce any coal during the sample period.

than regular provinces do, and thus, city leaders there may face quite different incentive contracts. In addition, we do not include Xinjiang, as the data on coal production and other socioeconomic variables in that province are only available for one city, Urumqi, in this province. This renders it infeasible to empirically examine the relative performance evaluation among coal-producing cities. In the second step, we pick out all the cities with positive coal productions throughout the sample period. Although the value of coal output may be small relative to GDP in some cities, safety stands out alone as an important issue as long as coal mines are in operation and the risk of disaster cannot be ignored. Cities with little coal production may have a strong incentive to compete on safety performance because the economic cost associated with the safety competition is small. Hence, coal mine safety carries a meaningful weight in the incentives of city leaders even if their coal production is small.

For the purpose of analysis, we focus on the period between 2001 and 2011. The data on coal mine disasters provided by SAWS are incomplete for many cities before 2001. By 2011, coal mine safety was significantly improved, and the majority of cities have had much fewer disasters since then. Figure 3 illustrates the cities that were included in the empirical analysis, featuring the spatial distribution of coal productions and coal mine deaths in the sample period. Table A1 in the appendix provides a full list of the cities used for the empirical analyses.

3.2 Coal Mine Deaths

The main variable of interest is the number of coal mine deaths in city i during year-quarter t. We take the logarithm of deaths, $log(1+\#\ deaths_{i,t})$, as the dependent variable to account for discrete distribution in the number of deaths. The main independent variable is the average of log deaths for all coal-producing cities that are defined as city i's "neighbors" in time t. We define a city j as i's *political neighbor* if j and i are located within the same province. An alternative definition relies on geographical distance, specifying neighbors as coal-producing cities that are located within a radius of 250 kilometers.[11] In section 5.2, we present the neighborhood effects based on the data from geographical, but not political, neighbors. Distinguishing between the two types of neighbors makes it possible to disentangle neighborhood effects due to the RPE from the

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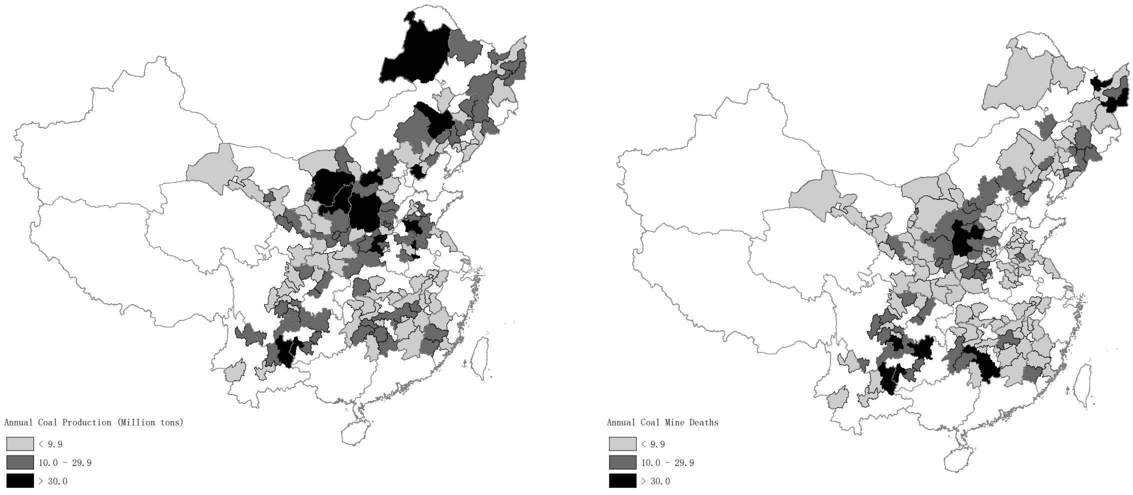
[11] The calculation of geographic distance between cities are the geodesic distance between the centers of the cities. We use the National-Standard longitude and latitude data set (GB 2206-2) as a reference for cities' locations.

Figure 3: Spatial Distribution of Coal Production and Deaths: Cities in the Sample



Notes: The left panel illustrates the spatial distribution of coal productions (2001-2011 average) in the cities included in the sample for analysis. The right panel illustrates the spatial distribution of coal mine deaths (2001-2011 average) in cities in the cities included in the sample.

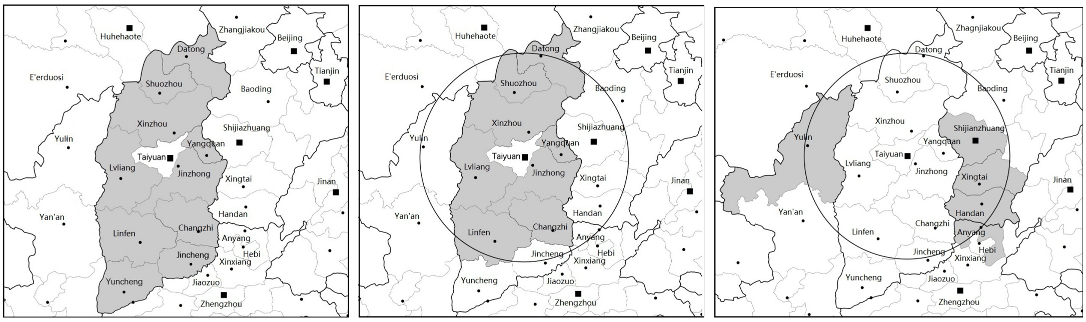
effects due to market interactions, since the RPE operates only within a province, and the market interaction goes beyond political jurisdiction. The definitions of the two types of neighbors are clarified by Figure 4. In section 5.3, we also estimate the neighborhood effects among cities that are economically comparable, the *economic neighbors*. City j is defined as city i's economic neighbor if in 2001 the difference in per capita GDP between the two cities is less than one standard deviation of China's per capita GDP.

3.3 Control Variables

Coal productions and other coal-related variables We obtain yearly data on coal production at the city level from the Statistics Yearbooks of provinces and cities, as well as the Yearbooks of Coal Industry. In all regressions, we control for the logarithm of coal productions to address the correlation between the rate of coal mine disasters and the level of production. As a robust check, we also estimate neighborhood effects with regard to the death rate, and report the results in the appendix.

Coal-related regulations We control for the number of regulatory decrees related to coal mine safety that are enacted by each provincial government in each year-quarter.

Figure 4: Political and Geographical Neighbors: An Illustration



(a) Political Neighbors (all, same province)

(b) Political Neighbors (250 km radius, same province)

(c) Geographical, Not Political Neighbors (250 km radius, other province)

Notes: The graphs illustrate the political neighbors, political as well as geographical neighbors, and geographical (but not political) neighbors of Taiyuan, the capital city of Shan'xi Province. Thick (thin) polylines represent provincial (city) borderlines. Squares and dots depict administrative centers of provincial capital cities and prefecture cities, respectively. Each of the two circles in the figures has a radius of 250 kilometers and is centered at Taiyuan City.

The information was obtained through a widely used database on administrative laws and government decrees in China, using "coal mine" and "safety" as keywords.[12] The number of new regulations on coal mine safety reflects the efforts of the provincial government to improve safety. The imposition of new regulatory rules is an indicator of the increasing salience of coal mine safety. Controlling the number of coal-related regulations helps deal with contextual interaction effects, such as provincial governments' policy interventions that impact city-level accidents in the same direction.

Characteristics of city leaders In section 5.7, we examine how neighborhood effects are shaped by the political incentives of city leaders. We try to capture the incentive by exploring two characteristics of city leaders: whether officials are close to the promotion age limit, and whether their birthplaces are in the same province in which they serve. To address the age effect, we construct a dummy variable to indicate whether a city party secretary is between ages 54 and 58. This range is the last, and most crucial, time window for city leaders to be promoted, due to the age limit implemented in the cadre system. We also test whether locally born leaders respond differently to neighbors' performance. The information on city leaders' age and birthplace was obtained from provincial and city yearbooks. We combine these with Internet sources such as *China Vitae* and *Baidu*

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[12] *http://www.pkulaw.cn/*.

Baike.[13]

Ranking on coal mine deaths In section 5.8, we look into city heterogeneity in performance and investigate whether the safety ranking may affect the incentives in responding to the neighbors' performance. The RPE for safety may be more critical for cities that are lagging behind. We compute a measure of cities' relative ranking on coal mine safety among all coal-producing cities in preceding quarters, and investigate the interaction between the ranking on safety and the magnitude of neighborhood effects.

Other workplace deaths In section 5.9, we estimate the neighborhood effects with respect to deaths in other industries, including non-coal mines, construction, and the manufacturing sector. The estimation uses the average of (log) other workplace deaths in the "neighborhood," which is calculated similarly as those of coal mine deaths, as an explanatory variable for city-level workplace death. The information on other types of workplace deaths is obtained from the same online database provided by SAWS.

Socioeconomic characteristics The magnitude of the neighborhood effects may be correlated with cities' socioeconomic conditions. In most estimations, we include a rich set of variables to control potential confounding factors of coal mine deaths, including yearly data on cities' log real GDP per capita, neighbors' average log real GDP per capita, log coal production, neighbors' average log coal production, percentage share of secondary industry in city-level GDP, log population density, and log freight transport. The data for the socioeconomic characteristics were collected from *China City Statistics Yearbooks*. Table 1 provides summary statistics for the main variables and the sources of information.

4 Empirical Strategy

The neighborhood effect on coal mine deaths is estimated by the following SAR model:

$$y_{i,t} = \beta \sum_{j \in N(i)} \omega_{ij} y_{j,t} + X_{i,t}\theta + \lambda_i + \eta_t + t \times d_p + \kappa_c \times d_p + \epsilon_{it}. \tag{1}$$

The dependent variable, $y_{i,t}$ in equation (1), represents the level of coal mine deaths in city i (of province p) throughout year-quarter t. The main specifications measure $y_{i,t}$ as $\log(1 + \#\ deaths_{i,t})$ to deal with discrete distribution of the number of deaths.[14] We

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[13] *China Vitae*: `http://chinavitae.com/`; *Baidu Baike*: `http://baike.baidu.com/`

[14] As a robustness check, in the appendix we use two alternate measures of $y_{i,t}$: (1) the hyperbolic

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Data Source
	City-Quarter Number of Deaths					
log(1 + Deaths)	7172	0.493	0.897	0	5.215	1
Avg. Neighbors' log(1 + Deaths)	7172	0.470	0.509	0	2.867	1
log(1 + Other Work Deaths)	7172	0.258	0.629	0	5.642	1
log(1 + Total Work Deaths)	7172	0.695	0.996	0	5.642	1
	City-Year Data					
log(Real GDP Per Capita) (ten thousand Yuan)	7172	1.564	0.391	0.407	2.482	2
GDP Share of Secondary Industry (Percentage Points)	7172	47.577	11.624	0	85.64	2
log(Population Density)(Persons/Sq.km)	7172	2.381	0.403	0.756	3.133	2
log(Freight Transport) (Ten Thousand Tons)	7172	3.679	0.368	2.029	4.801	2
log(Coal Production) (Ten Thousand Tons)	7172	2.383	1.004	0	4.769	3, 4
1(City Party Secretary's Age is Between 54 and 58)	7172	0.297	0.457	0	1	3, 5
1(City Party Secretary is Native)	6524	0.689	0.463	0	1	3, 5
	City-Quarter Data					
Ranking of Coal Mine Safety Conditions	7172	0	0.713	-1.073	5.879	1
1(Coal Mine Death > Provincial Avg.)	7172	0.225	0.417	0	1	1
	Province-Quarter Data					
# of Decrees by Provincial Government	7172	1.497	2.007	0	9	5

Notes: The sample covers 163 coal producing cities in 44 quarters from 2001 to 2011. For all year-level variables, the values are the same for the four quarters within each year, and we have 7,172 observations (163 cities in 44 quarters) for these variables. The safety ranking of city i in year t is computed as $rank_{d,i,t} \equiv \frac{d_{i,t}-m(d)_t}{sd(d)_t}$, where $d_{i,t}$ is i's deaths in quarter t, $m(d)_t$ is the mean of all cities' deaths in the province, and $sd(d)_t$ is the standard deviation of coal mine deaths in all cities within the province. Some missing values in log(Coal Production) and log(Freight Transport) are linearly interpolated.

Data sources:
1. State Administration of Work Safety websites
2. China City Statistics Yearbook
3. Statistics yearbooks of each city and province
4. China Coal Industry Yearbook
5. Internet Sources (such as China Vitae, Baidu, and Wikipedia)

understand $y_{i,t}$ as an indicator of safety performance, which is endogenously determined by local leaders' efforts to enhance their performance in comparison with those of their neighbors, $\sum_{j \in N(i)} \omega_{ij} y_{j,t}$. $j \in N(i)$ denotes cities located in i's neighborhood, and in the baseline it is defined as all cities that are from the same province p.[15] Because cities mainly compete with each other in political, rather than geographical, space we assume that each neighbor has equal impact on the efforts of i: $\omega_{ij} = \frac{1}{||N(i)||}$, where $||N(i)||$ is the number of cities in i's neighborhood.[16] In turn, the main parameter of interest is β, the coefficient on $\sum_{j \in N(i)} \omega_{ij} y_{j,t}$.

As introduced in section 3, $\mathbf{X_{it}}$ is a vector of control variables, which include the logarithm of real GDP per capita and coal production in the home city, the percentage share of secondary industries, and log population density. Because coal mine safety in neighboring cities is also affected by the socioeconomic variables, and because these variables may be spatially correlated, coal mine deaths may be confounded by $\mathbf{X_{jt}}$ for cities in the neighborhood, $j \in N(i)$. Therefore, we include the neighborhood-average corresponding to the control variables introduced above.

As Manski (2000) points out, neighborhood effects may stem from both endogenous and contextual interactions, and the identification of endogenous interaction is susceptible to omitted variable bias due to contextual effects. It is likely that coal mine deaths are correlated among geographically adjacent cities with similar geological conditions. Moreover, coal mine deaths in different cities may be affected by common shocks, such as technological upgrading in the coal mining industry or price shocks in the global market. To deal with region-level unobservable effects, we include a set of city dummies, λ_i, throughout all specifications. Including city fixed effects eliminates all time-invariant contextual interactions. Moreover, we control for year-quarter fixed effects, η_t, which eliminates time-varying shocks that impact all cities at the same time.

In addition to city and year-quarter fixed effects, coal mine deaths may be shaped by dynamic policy shocks in different provinces. Provincial governments have certain

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inverse sine of coal mine deaths, and (2) the logarithm of coal mine deaths normalized by production. The results are qualitatively identical to the baseline.

[15] In a departure from research on neighborhood effects among firms and households, in which the formation of the neighborhood is often endogenous, the scope of the political neighborhood is exogenously given and unaffected by self-sorting.

[16] In the appendix, we assign greater weights to cities with per capita GDP rankings closer to i. For city i, the neighbor j's weight is given by $\omega_{ij} = \frac{1(j \in P_i)|GDP_{i,2001} - GDP_{j,2001}|^{-1}}{\sum_k [1(k \in P_i)|GDP_{i,2001} - GDP_{k,2001}|^{-1}]}$, where $1(j \in P_i)$ is a dummy indicating whether j is in i's province P_i, and $GDP_{i,2001}$ is city i's per capita GDP in 2001. The results again are unchanged.

autonomy over safety regulation. In turn, cities in the same province may respond to province-specific shocks and exert correlated efforts. An ideal solution for dealing with these types of contextual effects would be to include province-year-quarter fixed effects. Such a method, however, is undesirable for estimating neighborhood effects, provided that the main explanatory variable of interest, $\sum_{j\in N(i)} \omega_{ij} y_{j,t}$, is by construction highly correlated with province-year-quarter fixed effects.[17] To deal with the problem of provincial time-varying effects, we include $t \times d_p$, a vector of provincial time trends, and $\kappa_c \times d_p$, province-specific time dummy for "two sessions."[18] Provincial time trends capture the effects of province heterogeneity in regulation enforcement leading to different rates of improvement on coal mine deaths. Controlling for province-specific effects for "two sessions" helps alleviate political cycle effects in coal mine deaths, as discussed in the literature (Nie, Jiang, and Wang, 2013). In addition to the fixed effects, we control for the number of regulatory statutes and decrees enacted by provincial governments in each year-quarter. Coal mine-related statutes and decrees provide an informative measure of administrative efforts on safety enhancements varying at the province-quarter level. Thus, this variable can be used as a proxy for dynamic provincial policy shocks. ϵ_{it} in equation (1) is the term for random disturbance.

The main challenge to the identification of the neighborhood effect is the reflection problem (Manski, 1993). In equation (1), $y_{i,t}$ and all $y_{j,t}$ for $j \in N(i))$ are simultaneously determined, and hence $\sum_{j\in N(i)} \omega_{ij} y_{j,t}$ is not orthogonal to random disturbance ϵ_{it}. As a result, the estimate for β through a linear regression following equation (1) is biased. We adopt two approaches to deal with this reflection problem. First, we adopt the method developed by Lee and Yu (2010) to fit equation (1) by using QML estimation. QML estimation provides a consistent estimator that takes into account the endogeneity due to spatial interdependence in the data, and the incidental parameter problems raised by incorporating fixed effects. It involves data transformation in the first step, which

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[17] This is because the political neighborhood includes all coal-producing cities except own city in computing $\sum_{j\in N(i)} \omega_{ij} y_{j,t}$. Consequently, $\sum_{j\in N(i)} \omega_{ij} y_{j,t}$ does not have enough of variation across different cities i and it is highly correlated with province-average coal mine deaths, or province-year-quarter dummies. In the appendix, we estimate neighborhood effects with a refined definition for political neighbors: all coal-producing cities that are from the same province and whose administrative center is located within 250 kilometers from that of city i. This measure produces enough variation of $\sum_{j\in N(i)} \omega_{ij} y_{j,t}$ for different cities i. We replicate the baseline results with additional controls of province-year-quarter fixed effects. The neighborhood effects are positive significant and the results are close to those in the baseline model presented in Table 2.

[18] "Two sessions" refer to the annual meeting of the National People's Congress and the Chinese People's Political Consultative Conference, which are often coupled with political appointments before or afterwards.

eliminates individual and time fixed effects, and then, in the second step, maximizing the likelihood function conditional on the transformed data. Different from traditional approaches of maximum likelihood estimation, it yields consistent estimates with properly centered distributions. We provide a brief note on the QML estimation in the appendix.

Second, we follow Fredriksson and Millimet (2002) and Aizer and Currie (2004) to use $\sum_{j\in N(i)} w_{ij}y_{j,t-1}$, the one-period time lag, as a substitute for neighbors' deaths in our specification. The rationale is that $y_{j,t-1}$ is closely related to $y_{j,t}$ but not directly correlated with ϵ_{it}. This specification implies a dynamic data generating-process for $y_{i,t}$, and hence we also need to include its one-period lag, $y_{i,t-1}$, in the right-hand side of the model. Formally, we revise equation (1) to the following dynamic model:

$$y_{i,t} = \alpha y_{i,t-1} + \beta \sum_{j\in N(i)} w_{ij}y_{j,t-1} + X_{i,t}\theta + \lambda_i + \eta_t + t \times d_p + \kappa_c \times d_p + \mu_l + \epsilon_{it}. \tag{2}$$

The dynamic model (2), however, introduces dynamic panel bias, which can only be mediated for large time periods (Nickell, 1981). With quarterly data, we have $T = 44$, a relatively large number of time periods for the dynamic model. For all the estimations, we cluster standard errors at the city level. We also follow the method proposed by Conley (1999) to allow spatial correlation of the error terms among cities located within a certain distance. In turn, we report spatial standard errors in all the linear regressions.[19]

5 Results

5.1 Baseline Results

Table 2 presents the baseline results of neighborhood effects on coal mine deaths, with neighbors defined as all other coal-producing cities in the same province. The coefficient on neighbors' average performance, β, is the main variable of interest. A positive β is consistent with the existence of endogenous interactions among cities due to the RPE. Columns 1 through 3 report the estimates based on the spatial autoregressive model using QML estimation. The estimations adopt contemporaneous terms of neighbors' deaths and do not include the lagged dependent variables. In column 1, we control city fixed effects, year-quarter fixed effects, and provincial time trends, along with the

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[19] The Stata codes are provided by Hsiang (2010).

control variables introduced in section 3. The coefficient for the spatial lag is 0.376 and statistically significant at the 0.01 level. Column 2 additionally controls for the province-specific effect of political cycles and yields similar results. In column 3, we include province-year-quarter fixed effects, which absorb all the provincial time trends and political cycles. The estimate of β is 0.334, and it remains significant at the 0.01 level. Because QML estimation accounts for all the fixed effects before maximizing the likelihood function, the collinearity between neighbors' averages and province-year-quarter dummies does not affect the standard errors of the estimated coefficients.

Columns 4 to 6 report the estimates based on linear regression of specification 2, which adopts the one-quarter lag of neighbors' average and controls for the lagged dependent variable, $y_{i,t-1}$. In columns 4 and 5, the control variables respectively replicate those in columns 1 and 2. The results are qualitatively similar: the results are statistically significant at the 0.01 level, and the estimates are smaller compared with those obtained using contemporaneous terms in the QML estimation. We also report spatial standard errors based on Conley (1999), which yield similar results as clustered standard errors. In column 6, we control for the the provincial-year-quarter fixed effects, and the coefficient drops to 0.054 and becomes insignificant. The standard error in column 6 is more than twice as large as those in columns 4 and 5. The large increase in the standard error in column 6 suggests considerable collinearity between neighbors' average deaths and provincial-year-quarter fixed effects, which absorbs a large part of the variation in the neighbors' average deaths. In Table A2 in the online appendix, we provide estimates with the 250-kilometer radius being additionally imposed as a condition for being a political neighbor. This restriction helps avoid the collinearity problem and produces enough variation in neighbors' average deaths while controlling for the provincial-year-quarter fixed effects. The results based on political neighbors within 250 kilometers are close to the baseline results and the coefficient remains statistically significant with the provincial-year-quarter fixed effects.

The estimated coefficients based on the contemporaneous terms are twice as large as those based on the lagged terms. This difference suggests that the impacts of past safety on the current performance may decline over time, presumably because the performance evaluation is conducted on a quarterly base. Hence, instantaneous interactions among local governments due to the concern of RPE may be stronger than those reactions to the past performance. Interestingly, as columns 4 and 5 illustrate, the lagged performance

Table 2: Neighborhood Effects: Baseline Results

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: log(1+ # of Coalmine Deaths)					
	QMLE	QMLE	QMLE	OLS	OLS	OLS
Avg. Neighbors' log(1+ Deaths), Same Province All	0.376***	0.369***	0.334***			
	(0.046)	(0.045)	(0.040)			
lag Avg. Neighbors' log(1+ Deaths), Same Province All				0.156***	0.182***	0.045
				(0.039)	(0.039)	(0.413)
lag Own log(1+ Deaths)				0.071***	0.073***	0.054
				(0.019)	(0.019)	(0.052)
Spatial Standard Error(200km)				[0.033]***	[0.032]***	[0.405]
Spatial Standard Error(250km)				[0.033]***	[0.032]***	[0.405]
Spatial Standard Error(300km)				[0.033]***	[0.033]***	[0.405]
Control Variables	Y	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y	Y
Quarter FE	Y	Y	Y	Y	Y	Y
Provincial Time Trends	Y	Y		Y	Y	
Provincial Political Cycles	N	Y		N	Y	
Province-Year-Quarter FE	N	N	Y	N	N	Y
Number of Cities	163	163	163	163	163	163
Observations	7172	7172	7172	7009	7009	7009
R-squared	0.261	0.272	0.389	0.232	0.237	0.346

Notes: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. Controls include own and neighbors' average log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial government. Standard errors reported in parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

of political neighbors has a larger impact on a city's performance than its own past performance. We attribute this finding to the significance of RPE in shaping the incentives of city officials.

5.2 Political Versus Geographic Neighbors

The baseline results attest to positive neighborhood effects on coal mine deaths. However, instead of endogenous interactions under the RPE, the neighborhood effects may stem from market interactions. Political jurisdictions that are geographically close may affect each other's policies and development outcomes through information spillovers and Tieboutian competition (Aidt and Franck, 2015; Belenzon and Schankerman, 2013; Brueckner and Saavedra, 2001; Case, Rosen, and Hines, 1993). If that is the predominant case in coal mine safety, we should expect two further results to follow: (1) cities respond more strongly to political neighbors that are closer to each other; and (2) cities respond to the safety performance of geographic neighbors that are located in other provinces. To address this possibility, we first assess the impact of average deaths among political neighbors within radii of 200, 250, and 300 kilometers. Then, we estimate neighborhood effects for geographic, but not political, neighbors within these radii.

Panel A in Table 3 presents the estimates with the revised definitions of neighbors. We observe that neighbors' average deaths exert a positive significant effect on the level of coal mine deaths in cities for all radii between 200 and 300 kilometers. The coefficients only slightly increase along with expansion of the radius and size of the political neighborhood, while the magnitude of the changes in the coefficient from columns 1 to 4 is pretty small. Columns 5 to 7 report the estimates for geographic neighbors located in other provinces. The coefficients corresponding to 200 and 250 kilometers are insignificant. The coefficient associated with neighbors within the radius of 300 kilometers is positive and significant; however, the size of the impact is much smaller – less than one-tenth of the estimates based on political neighbors within the radius of 300 kilometers. In panel B in Table 3, we report similar estimates using linear regressions with lagged variables. The results resonate with the baseline estimates in Table 2 and panel A in Table 3, in showing that (1) the level of political neighbors' deaths has a positive significant effect on cities' own deaths, and the size of the coefficient is half those obtained from the QML estimation using contemporaneous terms; and (2) the size of the coefficients with political neighbors almost does not change with the radius of neighborhood. Moreover, the estimates for non-

Table 3: Political Neighbors Versus Geographical Neighbors

				Panel A: QML Estimation Dependent Variable: log(1+ Deaths)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Cities in the Same Province				Cities in Other Provinces		
	200 km	250 km	300 km	All	200 km	250 km	300 km
Avg. Neighbors' log(1+ Deaths)	0.283***	0.309***	0.310***	0.369***	0.047	0.032	0.025**
	(0.040)	(0.041)	(0.042)	(0.045)	(0.035)	(0.018)	(0.011)
R-squared	0.258	0.260	0.261	0.272	0.202	0.200	0.204
Number of Cities	163	163	163	163	163	163	163
Observations	7172	7172	7172	7172	7172	7172	7172

				Panel B: OLS Estimation Dependent Variable: log(1+ Deaths)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Cities in the Same Province				Cities in Other Province		
	200 km	250 km	300 km	All	200 km	250 km	300 km
Avg. Neighbors' log(1+ Deaths)	0.123***	0.150***	0.173***	0.182***	0.026	-0.013	-0.038
	(0.031)	(0.032)	(0.035)	(0.039)	(0.025)	(0.027)	(0.034)
lag Own log(1+ Deaths)	0.077***	0.076***	0.074***	0.073***	0.081***	0.082***	0.083***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.0196)
Spatial Standard Error(200km)	[0.024]***	[0.026]***	[0.028]***	[0.032]***	[0.020]	[0.021]	[0.026]
Spatial Standard Error(250km)	[0.024]***	[0.027]***	[0.028]***	[0.032]***	[0.021]	[0.022]	[0.026]
Spatial Standard Error(300km)	[0.025]***	[0.027]***	[0.028]***	[0.033]***	[0.021]	[0.022]	[0.026]
R-squared	0.238	0.238	0.238	0.237	0.236	0.234	0.234
Number of Cities	163	163	163	163	163	163	163
Observations	7009	7009	7009	7009	7009	7009	7009

Notes: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

political neighbors are all insignificant, with coefficients being either negative or close to zero. The results in panels A and B prompt us to conclude that the neighborhood effects on coal mine safety that are identified in the baseline in Table 2 are predominantly generated by endogenous interactions among the cities that were evaluated and potentially in competition with each other in the same political jurisdiction, not market interactions among geographically neighboring cities. Alternative channels of neighborhood effects, such as information spillovers in market interactions, have at best small effects even if they may nevertheless exist.

5.3 City Hierarchy and Economic Neighbors

The results on neighborhood effects in coal mine safety that are reported in Tables 2 and 3 seem to support the logic of RPE among city officials. At the same time, the incentive of city officials to engage in political competition may be shaped by the political ranks of leaders and cities. Cities differ in their administrative ranks and level of development. The transfer of a local leader from a peripheral city to a central city would be considered as a promotion, even if the two cities have the same rank at the prefecture level (Li and Zhou, 2005). Local leaders being transferred from a prefecture-level city to a sub-provincial city holding the same positions is considered as being promoted without much ambiguity. In turn, competition may be likely to occur among local leaders with similar de facto political status, as indicated by the GDP ranking of cities. Yu, Zhou, and Zhu (2016) show that strategic competition on GDP growth is stronger when estimated among within-province neighbors with similar ranking of per capita GDP than in the case of within-province neighbors with only geographic proximity. If the logic of RPE extends to second-dimensional issues such as coal mine safety, it should be the case that the positive neighborhood effect is stronger among political neighbors with similar per capita GDP than among neighbors with more distant level of GDP.

To test this idea, we define two cities as economic neighbors if the difference in their per capita GDP in 2001 is within one standard deviation across cities. We examine whether the neighborhood effect on coal mine deaths is stronger among economic neighbors than merely political neighbors within the same province. The results presented in columns 1 and 2 in Table 4, using the QML estimation, support this argument. Within province, economically comparable cities have stronger interactions than economically distant cities in the same province do, notwithstanding significant and positive interactions for the latter group. In addition, we observe that cities do not move along with those with similar ranks on per capita but located in other provinces. The coefficient for neighborhood effects, if anything, is negative in Table 4. In columns 4 through 6, we reestimate the neighborhood effects using linear regression with lagged variables and obtain similar results. Overall, the pattern of neighborhood effects on coal mine safety is consistent with the pattern of GDP competition documented in the previous literature. Leaders of economically comparable cities are likely to be potential rivals for promotion. Hence, the significant neighborhood effect in coal mine deaths among them may suggest that the safety was a salient issue for the sample period we examine.

To explore further the link between political hierarchy and the incentives of local leaders, we supplement the baseline estimations with two more tests accounting for cities' ranks. We address the heterogeneity of provincial capitals and sub-provincial cities by interacting neighbors' deaths with dummies for the provincial capital and sub-provincial city. The results show that the neighborhood effects are not driven by particular patterns in these two types of cities. We also replicate the baseline estimations with a refined spatial weights matrix in which cities of higher economic proximity in terms of GDP ranking are given greater weight. The results are similar to the baseline of Table 2. We relegated the results of these two tests to Tables A4 and A5 in the online appendix.

5.4 Accounting for the Dynamics of Political Competition

In the baseline specification of Equation 2, cities only respond to the one-quarter lag of neighbors' safety performance. Because past performance also affects yearly evaluation, it is possible that higher-order time lags of neighbors' deaths affect a city's performance. Table 5 examines this possibility by using higher-ordered time lags of neighbors' deaths as explanatory variables. From columns 1 and 2 in Table 5, we observe that this dynamic neighborhood effect endures for two lagged periods, that is, a window of nine months. The result in column 2 shows a decline in the magnitude of the neighborhood effect on coal mine deaths over time.[20] This is probably unsurprising, as cities might already exert instantaneous efforts and respond to performance from political neighbors in response to the quarterly RPE. Thus, the current effort responds only partially to neighbors'

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[20] In Table 5, we do not include higher-order time lags together with the one period lag of neighbors' performance. As a robustness check, in Table A6 in the appendix, we include both first-order and second order lags of neighbors' deaths in the regressions. The coefficient on the second-order lag is no longer significant, implying that cities are primarily responsive to current information on political competition.

Table 4: Economically Comparable Cities

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: log(1+ Deaths)					
	QMLE			OLS		
Types of Neighbors	Economic, Within	Non-economic, Within	Economic, Across	Economic, Within	Non-economic, Within	Economic, Across
Avg. Neighbors' log(1+ Deaths)	0.278***	0.215***	-0.586***			
	(0.042)	(0.037)	(0.223)			
lag Avg. Neighbors' log(1+ Deaths)				0.120***	0.058***	-0.206*
				(0.029)	(0.018)	(0.121)
lag Own log(1+ Deaths)				0.077***	0.081***	0.081***
				(0.019)	(0.019)	(0.019)
Spatial Standard Error(200km)				[0.021]***	[0.012]***	[0.110]**
Spatial Standard Error(250km)				[0.021]***	[0.012]***	[0.111]**
Spatial Standard Error(300km)				[0.022]***	[0.012]***	[0.112]**
Number of Cities	163	163	163	163	163	163
Observations	7172	7172	7172	7,009	7,009	7,009
R-squared	0.258	0.239	0.215	0.237	0.235	0.234

Notes: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table 5: The Dynamics of the Neighborhood Effects: Higher Order Time Lags

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS Estimation									
	Dependent Variable: log(1+ Deaths)									
	Full Sample				In the Same Calendar Year			Not in the Same Calendar Year		
lag 1 Avg. Neighbors' log(1+ Deaths)	0.182***				0.214***			0.138**		
	(0.039)				(0.046)			(0.065)		
lag 2 Avg. Neighbors' log(1+ Deaths)		0.082**				0.122**			0.064	
		(0.034)				(0.048)			(0.048)	
lag 3 Avg. Neighbors' log(1+ Deaths)			0.033				0.072			0.017
			(0.032)				(0.071)			(0.040)
lag 4 Avg. Neighbors' log(1+ Deaths)				-0.057						
				(0.037)						
lag Own log(1+ Deaths)	0.073***	0.083***	0.076***	0.073***	0.089***	0.131***	0.187***	0.048	0.034	0.053**
	(0.019)	(0.019)	(0.020)	(0.021)	(0.020)	(0.024)	(0.034)	(0.035)	(0.028)	(0.023)
Spatial Standard Error(200km)	[0.032]***	[0.032]**	[0.032]	[0.036]	[0.040]***	[0.041]***	[0.065]	[0.065]**	[0.047]	[0.038]
Spatial Standard Error(250km)	[0.032]***	[0.032]**	[0.032]	[0.037]	[0.040]***	[0.042]***	[0.065]	[0.065]**	[0.047]	[0.039]
Spatial Standard Error(300km)	[0.033]***	[0.033]**	[0.032]	[0.036]	[0.041]***	[0.042]***	[0.066]	[0.065]**	[0.048]	[0.040]
R-squared	0.237	0.243	0.245	0.251	0.246	0.261	0.271	0.215	0.234	0.254
Number of Cities	163	163	163	163	163	163	163	163	163	163
Observations	7009	6846	6683	6520	5379	3586	1793	1630	3260	4890

Notes: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table 6: Neighborhood Effects with Yearly Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	QML Estimation Dependent Variable: log(1+ Deaths)						
	Cities in the Same Province				Cities in Other Provinces		
Avg. Neighbors' log(1+ Yearly Deaths)	200 km	250 km	300 km	All	200 km	250 km	300 km
	0.227***	0.249***	0.249***	0.319***	-0.050	-0.021	-0.029
	(0.043)	(0.047)	(0.048)	(0.050)	(0.047)	(0.026)	(0.017)
Control Variables	Y	Y	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y	Y	Y	Y
R-squared	0.521	0.521	0.521	0.532	0.496	0.493	0.501
Number of Cities	163	163	163	163	163	163	163
Observations	1793	1793	1793	1793	1793	1793	1793
	OLS Estimation (Dynamic Effects) Dependent Variable: log(1+ Deaths)						
	Cities in the Same Province				Cities in Other Provinces		
lag. Avg. Neighbors' log(1+ Yearly Deaths)	-0.0104	0.0523	-0.154	-0.386	0.0617	0.113	0.0722
	(0.0912)	(0.114)	(0.153)	(0.639)	(0.0685)	(0.0762)	(0.0968)
lag. Own log(1+ Yearly Deaths)	-0.0306	-0.0222	-0.0488	-0.074	-0.0311	-0.0315	-0.0360
	(0.0349)	(0.0351)	(0.0374)	(0.086)	(0.0326)	(0.0321)	(0.0318)
Control Variables	Y	Y	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y	Y	Y	Y
R-squared	0.509	0.508	0.509	0.509	0.510	0.510	0.512
Number of Cities	163	163	163	163	163	163	163
Observations	1,630	1,630	1,630	1,630	1,630	1,630	1,630

Notes: The sample covers 163 coal producing cities and 11 years from 2001 to 2011. In all columns city and province-year fixed effects are included. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. * Significant at 10%, ** 5%, *** 1%.

past performance. As we observe from column 3 and 4, the magnitude of the dynamic neighborhood effect shrinks after the third lagged period, that is, for 10 to 12 months from the current period on. Interestingly, when we restrict the definition of past performance to those in the same calendar year, the size of estimated coefficients increases by half, as shown in columns 5 and 6 of Table 5. By contrast, the coefficients are smaller, and significant for only one legged period across the same calendar year (columns 8 to 10).

The discrepancy in the results for higher-order time lags between the within-year and across-year samples is consistent with the logic of RPE for local leaders in China, which is mainly taken on an annual basis. Two further implications from these results are that (1) the neighborhood effects on coal mine deaths should also be present among political neighbors for yearly indicators of performance; and (2) when investigated on a yearly basis, the neighborhood effects may not exist for performances across different years. Political promotion for local leaders can occur any time throughout a political cycle. When city officials are fully responsive, the adjustment of efforts may have been taken promptly.

In Table 6, we estimate the neighborhood effects with QML estimation, with the yearly data on contemporaneous terms. The estimations include all the same control variables as in Table 2, as well as city fixed effects and province-year fixed effects. The results are similar to those obtained using quarterly data: the neighborhood effects are positive and significant for political neighbors within the same province, but not for geographically proximate neighbors in other provinces. Furthermore, the ostensible difference between the estimates using contemporaneous terms and cross-year data suggest that the effects are not driven by common trends in policy shocks. If that was the case, cities' own deaths should be spuriously associated with the higher-order time lags of the neighbors' safety performance, and neighbors' performance in the preceding year may serve as a proxy for the long-term time trends in regulatory policies that are unrelated to the RPE. The results in Tables 5 and 6 do not support this hypothesis.

5.5 Accounting for Misreporting

The recent literature raises a legitimate concern about the quality of administrative data in China (Fisman and Wang, 2016; Holz, 2014; Rawski, 2001; Wallace, 2016). In the context of coal mine safety, we need to address the possibility that the estimated neighborhood effects are driven by contextual effects due to the quality of the official data. Two kinds of measurement errors on coal mine deaths may pose a threat to identification.

First, local regulatory agencies may differ in their capacity for timely processing and reporting of disasters. Although the central government makes it mandatory for regulators to file reports within 24 hours after each coal mine disaster,[21] in practice, peripheral regions may be able to report deaths at a lower rate. Misreporting due to limited capacity tends to bias the estimates upward, but only if local leaders with stronger incentives cluster in regions with higher bureaucratic capacity. The cross-region variation in bureaucratic capacity should be stable over time and can be addressed by city fixed effects.

The second kind of measurement error stems from intentional cheating on coal mine accident reports. Fisman and Wang (2016) examine accidental deaths at the province-quarter level and document a discontinuity in the distribution at the "death ceilings," the self-imposed targets of safety set by provincial governments. The discontinuity suggests possible report manipulation by local governments. However, the existence of manipulation need not undermine the estimation of the effect of neighborhood effects on coal mine deaths, because manipulation only occurs when the underlying true values of coal mine deaths are close to the "death ceilings". As the overall distribution of deaths is quite dispersed and in most cases far below the thresholds, it is unlikely that manipulation alone is driving our estimates.[22]

We adopt two tests to investigate whether strategic misreporting is biasing up the estimates of neighborhood effects. First, we replicate the baseline estimations in Table 2 using the baseline sample excluding the fourth quarter. In Fisman and Wang (2016), strategic misreporting is evident only when including the fourth-quarter data. Because local leaders pay more attentions to safety near the end of the year when annual performance evaluations are finally conducted, this is interpreted as evidence of manipulation. If the neighborhood effects are driven by systematic manipulation, we should expect no results to appear when excluding the fourth-quarter data. Panel A in Table 7 shows this is not the case. Second, we estimate neighborhood effects with an additional interaction term between the city's distance to the provincial capital and the average of neighbors' deaths. When a city is located farther from the administrative center, the supervision cost is higher and manipulation becomes more prevalent. Hence, farther-away cities are more

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[21] *The Note on the Reports and Statistics of Coal Mine Disasters and Deaths* (*Meitan Gongye Qiye Zhigong Shangwang Shigu Baogao he Tongji Guiding*), implemented by the Ministry of Coal Industry on February 14, 1995. Retrieved at `http://www.chinasafety.gov.cn/file/fgmt/aqfg10.htm`

[22] Another possibility is that city leaders may engage in two activities at the same time: suppressing reports on coal mine disasters and exerting real efforts to improve safety. In this case, manipulation and real efforts push the neighborhood effects toward the same direction and it is difficult to disentangle two effects, as pointed out by Fisman and Wang (2016).

Table 7: Are the Neighborhood Effects Driven by Manipulation?

	Panel A: Excluding All 4th Quarters			
	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths)			
	Cities in the Same Province			
	200 km	250 km	300 km	All
lag Avg. log(1+ Deaths)	0.129***	0.155***	0.175***	0.173***
	(0.035)	(0.037)	(0.037)	(0.044)
Spatial S.E. (200km)	[0.027]***	[0.029]***	[0.033]***	[0.038]***
Spatial S.E. (250km)	[0.028]***	[0.030]***	[0.033]***	[0.039]***
Spatial S.E. (300km)	[0.028]***	[0.031]***	[0.034]***	[0.038]***
R-squared	0.239	0.241	0.241	0.240
Number of Cities	163	163	163	163
Observations	5216	5216	5216	5216

	Panel B: Interacting with Distance to Provincial Capital			
	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths)			
	Cities in the Same Province			
	200 km	250 km	300 km	All
lag Avg. log(1+ Deaths)	0.138*	0.136*	0.144*	0.149*
	(0.058)	(0.080)	(0.0859)	(0.0856)
lag Avg. log(1+ Deaths) * log(1+Distance)	-0.007	0.006	0.014	0.020
	(0.072)	(0.037)	(0.039)	(0.041)
R-squared	0.236	0.238	0.238	0.237
Number of Cities	163	163	163	163
Observations	7,009	7,009	7,009	7,009

Notes: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

likely to manipulate and would appear to be more "responsive." The interaction term should be positive following this logic. Panel B in Table 7 shows that the coefficients on the interaction terms are insignificant and small. On top of that, neighbors' performance remains significant at the 0.1 level and the magnitudes of the coefficients are similar to those in the baseline. Hence, the premise that the estimated neighborhood effects are driven by strategic misreporting is not supported by empirical evidence.

5.6 Regulatory Overhauls and National Political Cycles

Understanding neighborhood effect through the lens of the RPE on local leaders helps clarify the respective roles of centralization and decentralization in shaping the overall performance on coal mine safety. As Xu (2011) argues, the Chinese political system is both decentralized and centralized. Importantly, the RPE on local leaders empower the central government, helping translate the policy goals of the central government into a tangible competition on specific policies. In the simple model in the appendix, we show that, under reasonable conditions, the principal may be able to shape agents' efforts by calibrating the incentive scheme. This result implies that the size of the neighborhood effect on a specific policy tends to increase when the principal attaches more importance to it. As we discuss in Section 2, the most substantial and far-reaching reforms occurred in 2005, when SAWS was upgraded to a ministry with direct jurisdictions over local regulatory agencies, and when the central government implemented new rules to make subnational leaders, including provincial governors and party secretaries, accountable for workplace accidents. In this context, the increased size of the neighborhood effect in coal mine deaths is consistent with the improvement on coal mine safety in the post-2005 years.

To examine the impact of nation-level shocks, we estimate neighborhood effects with the interaction between the dummy indicating the post-2005 years and the average of neighbors' deaths. If the underlying mechanism of the neighborhood effect is consistent with the logic of RPE, we should observe a positive interactive term. We also interact the average of neighbors' deaths with the time span to the coming National Congress of the CCP (in quarters). We expect the latter to be negative, as moving toward the National Congress of the CCP (decreased time span) increases the salience of coal mine safety. Table 8 presents the estimates using dynamic linear models. Columns 1 and 2 show that the neighborhood effect is stronger in the post-2005 years, a finding that is

Table 8: Impacts of Policy Changes at the National Level

	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ Deaths)			
lag Avg. Neighbors' log(1+ deaths)	0.084*	0.097**	0.240***	0.246***
	(0.048)	(0.046)	(0.052)	(0.059)
lag Avg. Neighbors' log(1+ deaths) *1(After 2005)	0.140***	0.169***		
	(0.048)	(0.049)		
lag Avg. Neighbors' log(1+ deaths) * (Quarters to the Next Party Congress)			-0.010**	-0.007*
			(0.004)	(0.004)
Control Variables	Y	Y	Y	Y
City FE	Y	Y	Y	Y
Year-Quarter FE	Y	Y	Y	Y
Province-Quarter Time Trends	Y	Y	Y	Y
Provincial Political Cycles	N	Y	N	Y
R-squared	0.233	0.239	0.234	0.238
Number of Cities	163	163	163	163
Observations	7,009	7,009	7,009	7,009

Notes: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. Neighbors are defined as all other coal-producing cities in the same province. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

consistent with the empowerment of SAWS and improvement in coal mine safety in that period. Columns 3 and 4 show that the neighborhood effects get stronger when the date is closer to National Congress of the CCP, a finding in accordance with the literature on political cycles in developing countries (Block, 2002; Guo, 2009; Shi and Svensson, 2006). We interpret both results to be supportive evidence for the proposition that RPE helps induce neighborhood effects in coal mine deaths.

5.7 City Leaders' Characteristics

We explore the possibility that the response to neighbors' safety performance may vary according to city leaders' personal characteristics. We focus on the age and birthplace of city party secretaries. The incentive for city leaders to exert effort is structured by the retirement age limit in the Chinese system. As city leaders are mandated to retire officially at age 60, and exemptions for retirement are only occasionally made, the political incentive for promotion competition shrinks toward the age of 60. Indeed, city leaders are normally transferred to ceremonial positions with the same rank one or two years before reaching age 60 (Kou and Tsai, 2014). By the token of electoral politics, the official becomes a lame duck within a few years before reaching retirement age. This reasoning implies that there may be a spike in political incentive for city leaders some years before approaching the retirement age limit. To capture this effect, we construct a dummy variable indicating that the official is between ages 54 and 58, which is equivalent to the length of a full political cycle right before the official becomes a lame duck.

Columns 1 and 2 in Table 9 report the estimates of the neighborhood effects, with neighbors' performance interacted with the described age dummy. The coefficient for neighborhood effects remains positive and significant. The estimated coefficient for the interaction term is positive, but small and statistically insignificant. This result suggests that the responses of city leaders to neighbors' performance do not vary with their ages. We attribute the age-invariance of neighborhood effects to the multi-tasking situation faced by local leaders. City leaders with strong promotion incentives do not respond more or less than other age cohorts to coal mine safety, perhaps because competition on GDP growth remains a primary dimension of the RPE.

We also account for the heterogeneous responses of city leaders who were born in the same province where they served in the position of party secretary. Following the recent literature on state-business collusion in the Chinese political economy (Jia and Nie, 2015),

Table 9: Heterogeneity in City Secretaries' Age and Home Origin

	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths)			
lag. Avg. Neighbors' log(1+ deaths)	0.138***	0.166***	0.250***	0.286***
	(0.042)	(0.042)	(0.057)	(0.059)
$1(54 \leq Age \leq 58)$	-0.036	-0.035		
	(0.032)	(0.033)		
1(City Secretary is Native)			0.040	0.040
			(0.042)	(0.042)
lag. Avg. Neighbors' log(1+ deaths)* $1(54 \leq Age \leq 58)$	0.060	0.056		
	(0.052)	(0.052)		
lag. Avg. Neighbors' log(1+ deaths)*1(City Secretary is Native)			-0.140**	-0.144**
			(0.058)	(0.058)
Control Variables	Y	Y	Y	Y
City FE	Y	Y	Y	Y
Year-Quarter FE	Y	Y	Y	Y
Province-Quarter Time Trends	Y	Y	Y	Y
Provincial Political Cycles	N	Y	N	Y
R-squared	0.233	0.238	0.233	0.238
Number of Cities	163	163	163	163
Observations	7,009	7,009	7,009	7,009

Notes: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. Neighbors are defined as all other coal-producing cities in the same province. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

we expect that city leaders who were "locally" born may have lower costs to collude with local mining firms, and are hence less responsive to the goal of enhancing coal mine safety. The results in columns 3 and 4 in Table 9 show that neighborhood effect are weaker in cities where party secretaries have local ties measured by birthplace. By contrast, the incentive of city leaders who were not locally born seems to be more aligned with the goal of the central government.

5.8 Death Rankings

Another source of city heterogeneity in response to the level of coal mine deaths in political neighbors is cities' relative status on safety compared with neighbors' average. Consistent with the logic of RPE, cities falling behind on coal mine safety face a bad prospect in promotion competition. City leaders may have to exert greater effort in keeping up with neighbors, particularly when there is an overall trend of improvement in coal mine safety nationwide. To allow for differential responses depending on cities' safety conditions, we construct two measures: (1) a continuous index of coal mine deaths of city i's in time t, $\mathrm{R_{d,i,t}} \equiv \frac{\mathrm{d_{i,t}} - \mathrm{m(d)_t}}{\mathrm{sd(d)_t}}$, where $\mathrm{d_{i,t}}$ is the number of deaths in city i at time t, $\mathrm{m(d)_t}$ is the city average number of deaths in the province, and $\mathrm{sd(d)_t}$ is the standard deviation of city-level deaths; and (2) a dummy variable indicating whether the level of the city's coal mine deaths in time t is above the provincial average. We then estimate neighborhood effects with dynamic linear models, controlling for the interaction between the safety index of city i and the average term for neighbors' deaths.

Columns 1 and 2 in Table 10 report the estimates with the indicator of cities' safety status in the preceding quarter. The coefficient of the lagged term $\mathrm{R_{d,i,t}}$ is negative and significant, a sign that cities with previous higher deaths may have exerted greater effort to enhance coal mine safety. Thus, improvements on coal mine safety may be made in following periods.[23] Moreover, the coefficient on the interactive term between neighbors' deaths and $\mathrm{R_{d,i,t}}$ is positive, and this suggests stronger responses from cities that previously had more casualties compared with their neighbors. In columns 3 and 4, we replace the continuous index $\mathrm{R_{d,i,t}}$ with a dummy variable indicating whether the level of coal mine deaths is above the provincial average. The dummy variable does not appear to matter in itself; however, the interactive term is similarly positive and significant. We interpret the asymmetric response of cities depending on their safety ranking as suggestive

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[23] Note that $\mathrm{R_{d,i,t}}$ is measured by coal mine deaths, so it is inversely related to the level of safety.

Table 10: Heterogeneity in Cities' Rankings on Deaths

	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths)			
lag Avg. neighbors' log(1+ Deaths)	0.123***	0.151***	0.080**	0.107***
	(0.043)	(0.043)	(0.039)	(0.039)
lag Ranking of City's Death	-0.308***	-0.306***		
	(0.036)	(0.036)		
lag 1(Deaths > Provincial Avg.)			-0.095	-0.096
			(0.068)	(0.067)
lag Avg. neighbors' log(1+ Deaths)* Lag Ranking of City's Death	0.130***	0.130***		
	(0.033)	(0.032)		
lag Avg. neighbors' log(1+ Deaths)* Lag 1(Deaths > Provincial Avg.)			0.333***	0.332***
			(0.051)	(0.051)
Control Variables	Y	Y	Y	Y
City FE	Y	Y	Y	Y
Quarter FE	Y	Y	Y	Y
Province-Quarter Time Trends	Y	Y	Y	Y
Provincial Political Cycles	N	Y	N	Y
R-squared	0.248	0.253	0.241	0.246
Number of Cities	163	163	163	163
Observations	7,009	7,009	7,009	7,009

Note: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. Neighbors are defined as all other coal-producing cities in the same province. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

evidence for the use of RPE on coal mine safety.

5.9 Other Work Deaths

Coal mine safety is one of the recently improved policy domains in China. As the logic of RPE is general, it is interesting to investigate whether neighborhood effects exist for more comprehensive measures, such as total and other types of workplace deaths. Tables 11 and 12 replicate the estimates of neighborhood effects in a similar fashion as in Table 3, replacing the measure of coal mine deaths with total and other types of workplace deaths. Table 11 documents a similar pattern of neighborhood effects among coal-producing cities for total workplace deaths, which exist among political neighbors but not geographic neighbors from other provinces. When we turn to other types of workplace safety, neighborhood effects do not appear to be significant, as Table 12 reports. The other workplace accidents, such as those in non-coal mines, manufactures, and constructions, may not be a focal point in the RPE as the deaths from other accidents constitute only a small portion of total work deaths. Compared with coal mine deaths, there were no large declines in the recent decades, as reported by Figure 2 in section 2. As a result, strategic interactions among local governments on coal mine safety may have been a major driving force of neighborhood effects in total workplace deaths.

6 Conclusion

In this paper, we propose that the logic of RPE implies neighborhood effects on policies with high salience, and empirically study the effects in coal mine safety among prefecture-level cities in China. The main finding is that the level of coal mine deaths is positively associated with those of the cities' political neighbors within the same province, but not with those of their geographical neighbors from other provinces. Although one should keep in mind the caveat that it is impractical to exclude all contextual interactions behind the neighborhood effects, several tests with regard to region heterogeneity and dynamic effects suggest that inter-city competition under the RPE is a plausibly significant force of shaping the neighborhood effects.

Promotion competition along the line of economic growth is well established in the political-economic literature on China, however, less has been known about whether second-dimensional issues account for the incentives of local leaders. Our findings echo

Table 11: Total Work Deaths

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent Variable: log(1+ Total Deaths)						
	Cities in the Same Province				Cities in Other Provinces		
	200 km	250 km	300 km	All	200 km	250 km	300 km
Avg. lag log(1+ Total Work Deaths)	0.092***	0.120***	0.138***	0.149***	0.022	-0.040	-0.053
	(0.028)	(0.032)	(0.034)	(0.038)	(0.024)	(0.026)	(0.034)
lag log(1+ Total Deaths)	0.060***	0.060***	0.059***	0.057***	0.060***	0.060***	0.060***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Spatial S.E. (200km)	[0.021]***	[0.025]***	[0.027]***	[0.031]***	[0.017]	[0.017]	[0.026]
Spatial S.E. (250km)	[0.021]***	[0.025]***	[0.028]***	[0.031]***	[0.018]	[0.017]	[0.026]
Spatial S.E. (300km)	[0.022]***	[0.025]***	[0.0228***	[0.031]***	[0.018]	[0.018]	[0.027]
R-squared	0.167	0.168	0.169	0.169	0.167	0.167	0.167
Number of Cities	163	163	163	163	163	163	163
Observations	7,009	7,009	7,009	7,009	7,009	7,009	7,009

Panel B: Quasi-ML Estimation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent Variable: log(1+ Total Deaths)						
	Cities in the Same Province				Cities in Other Provinces		
	200 km	250 km	300 km	All	200 km	250 km	300 km
Avg. log(1+ Total Work Deaths)	0.224***	0.215***	0.246***	0.316***	0.038	0.029	0.024
	(0.049)	(0.051)	(0.052)	(0.055)	(0.041)	(0.20)	(0.013)
R-squared	0.191	0.193	0.192	0.210	0.157	0.157	0.161
Number of Cities	163	163	163	163	163	163	163
Observations	7172	7172	7172	7172	7172	7172	7172

Note: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table 12: Other Workplace Deaths

	Panel A: QML Estimation						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent Variable: log(1+ Other Work Deaths)						
	Cities in the Same Province				Cities in Other Provinces		
	200 km	250 km	300 km	All	200 km	250 km	300 km
Avg. Neighbors log(1+ Other Deaths)	0.044	0.063	0.041	0.063	0.004	0.023	0.010
	(0.159)	(0.171)	(0.177)	(0.168)	(0.113)	(0.107)	(0.036)
R-squared	0.025	0.023	0.025	0.028	0.025	0.023	0.024
Number of Cities	163	163	163	163	163	163	163
Observations	7172	7172	7172	7172	7172	7172	7172
	Panel B: OLS Estimation						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent Variable: log(1+ Other Deaths)						
	Cities in the Same Province				Cities in Other Provinces		
	200 km	250 km	300 km	All	200 km	250 km	300 km
Avg. lag Neighbors log(1+ Other Deaths)	-0.001	-0.012	0.004	0.012	-0.022	-0.027	-0.022
	(0.028)	(0.029)	(0.032)	(0.038)	(0.019)	(0.023)	(0.033)
lag log(1+ Other Deaths)	0.015	0.015	0.015	0.015	0.015	0.015	0.015
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Spatial Standard Error(200km)	[0.021]	[0.022]	[0.026]	[0.031]	[0.011]	[0.015]	[0.026]
Spatial Standard Error(250km)	[0.022]	[0.022]	[0.026]	[0.032]	[0.011]	[0.015]	[0.026]
Spatial Standard Error(300km)	[0.022]	[0.023]	[0.027]	[0.032]	[0.012]	[0.015]	[0.027]
R-squared	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Number of Cities	163	163	163	163	163	163	163
Observations	7,009	7,009	7,009	7,009	7,009	7,009	7,009

Note: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average of log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial governments. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

the previous arguments that incentives of local officials may be important in shaping the performance on second-dimensional policies such as environmental regulation (Foulon, Lanoie, and Laplante, 2002; Gagnepain and Ivaldi, 2002; Zheng et al., 2014; Zhuravskaya, 2000). Like the issue of environmental regulation, coal mine safety becomes increasingly important for local governments in the recent years because of its salience in the RPE for local leaders. The effects of top-down interventions on these policies could be amplified when RPE is introduced to incentivize local officials.

References

Acemoglu, Daron, Camilo Garcia-Jimeno, and James A Robinson. 2015. "State capacity and economic development: A network approach." *The American Economic Review* 105 (8):2364–2409.

Aidt, Toke S and Raphaël Franck. 2015. "Democratization under the threat of revolution: Evidence from the Great Reform Act of 1832." *Econometrica* 83 (2):505–547.

Aizer, Anna and Janet Currie. 2004. "Networks or neighborhoods? Correlations in the use of publicly-funded maternity care in California." *Journal of Public Economics* 88 (12):2573–2585.

Belenzon, Sharon and Mark Schankerman. 2013. "Spreading the word: Geography, policy, and knowledge spillovers." *Review of Economics and Statistics* 95 (3):884–903.

Besley, Timothy and Anne Case. 1995. "Incumbent Behavior: Vote-Seeking, Tax-Setting, and Yardstick Competition." *American Economic Review* 85 (1):25–45.

Block, Steven A. 2002. "Political business cycles, democratization, and economic reform: the case of Africa." *Journal of Development Economics* 67 (1):205–228.

Bloom, Nicholas, Mark Schankerman, and John Van Reenen. 2013. "Identifying technology spillovers and product market rivalry." *Econometrica* 81 (4):1347–1393.

Bordignon, Massimo, Floriana Cerniglia, and Federico Revelli. 2003. "In search of yardstick competition: a spatial analysis of Italian municipality property tax setting." *Journal of Urban Economics* 54 (2):199–217.

Brueckner, Jan K and Luz A Saavedra. 2001. “Do Local Governments Engage in Strategic Property–Tax Competition?” *National Tax Journal* 54 (2):203–230.

Cai, Meina. 2012. *Land-Locked Development: The Local Political Economy of Institutional Change in China. Ph.D. Dissertation.* Madison, WI: University of Wisconsin-Madison.

Callander, Steven and Bård Harstad. 2015. “Experimentation in federal systems.” *The Quarterly Journal of Economics* 130 (2):951–1002.

Case, Anne C, Harvey S Rosen, and James R Hines. 1993. “Budget spillovers and fiscal policy interdependence: Evidence from the states.” *Journal of public economics* 52 (3):285–307.

Chen, Ting and James Kung. 2016. “Do land revenue windfalls create a political resource curse? Evidence from China.” *Journal of Development Economics* 123:86–106.

Conley, Timothy G. 1999. “GMM estimation with cross sectional dependence.” *Journal of Econometrics* 92 (1):1–45.

Figlio, David N, Van W Kolpin, and William E Reid. 1999. “Do states play welfare games?” *Journal of Urban Economics* 46 (3):437–454.

Fisman, Raymond and Yongxiang Wang. 2016. “The distortionary effects of incentives in government: Evidence from China’s death ceiling program.” *American Economic Journal: Applied Economics* .

Foulon, Jérôme, Paul Lanoie, and Benoıt Laplante. 2002. “Incentives for pollution control: regulation or information?” *Journal of Environmental Economics and Management* 44 (1):169–187.

Fredriksson, Per G and Daniel L Millimet. 2002. “Strategic interaction and the determination of environmental policy across US states.” *Journal of Urban Economics* 51 (1):101–122.

Gagnepain, Philippe and Marc Ivaldi. 2002. “Incentive regulatory policies: the case of public transit systems in France.” *RAND Journal of Economics* :605–629.

Gallagher, Mary E. 2002. ““Reform and openness”: why China’s economic reforms have delayed democracy.” *World Politics* 54 (03):338–372.

Guo, Gang. 2009. “China’s local political budget cycles.” *American Journal of Political Science* 53 (3):621–632.

Holmstrom, Bengt. 1982. “Moral hazard in teams.” *Bell Journal of Economics* 13 (2):324–340.

Holz, Carsten A. 2014. “The quality of China’s GDP statistics.” *China Economic Review* 30:309–338.

Hsiang, Solomon M. 2010. “Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America.” *Proceedings of the National Academy of Sciences* 107 (35):15367–15372.

Jia, Ruixue and Huihua Nie. 2015. “Decentralization, Collusion and Coalmine Deaths.” *Review of Economics and Statistics* .

Jin, Hehui, Yingyi Qian, and Barry Weingast. 2005. “Regional decentralization and fiscal incentives: Federalism, Chinese style.” *Journal of Public Economics* 89 (9):1719–1742.

Kou, Chien Wen and Wen Hsuan Tsai. 2014. “Sprinting with small steps towards promotion: Solutions for the age dilemma in the CCP cadre appointment system.” *The China Journal* (71):153–171.

Lazear, Edward P and Sherwin Rosen. 1981. “Rank-Order Tournaments as Optimum Labor Contracts.” *Journal of Political Economy* 89 (5):841–864.

Lee, Lung-fei and Jihai Yu. 2010. “Estimation of spatial autoregressive panel data models with fixed effects.” *Journal of Econometrics* 154 (2):165–185.

Li, Hongbin and Li-An Zhou. 2005. “Political turnover and economic performance: the incentive role of personnel control in China.” *Journal of Public Economics* 89 (9):1743–1762.

List, John A, Daniel M Strum, and Daniel M Sturm. 2006. “How elections matter: theory and evidence from environmental policy.” *Quarterly Journal of Economics* 121 (4).

Lü, Xiaobo and Pierre F Landry. 2014. “Show me the money: Interjurisdiction political competition and fiscal extraction in China.” *American Political Science Review* 108 (03):706–722.

Lyytikäinen, Teemu. 2012. “Tax competition among local governments: Evidence from a property tax reform in Finland.” *Journal of Public Economics* 96 (7):584–595.

Manski, Charles F. 1993. “Identification of endogenous social effects: The reflection problem.” *Review of Economic Studies* 60 (3):531–542.

———. 2000. “Economic Analysis of Social Interactions.” *Journal of Economic Perspectives* 14 (3):115–136.

Markusen, James R, Edward R Morey, and Nancy Olewiler. 1995. “Competition in regional environmental policies when plant locations are endogenous.” *Journal of Public Economics* 56 (1):55–77.

Munshi, Kaivan. 2004. “Social learning in a heterogeneous population: technology diffusion in the Indian Green Revolution.” *Journal of Development Economics* 73 (1):185–213.

Nickell, Stephen. 1981. “Biases in dynamic models with fixed effects.” *Econometrica: Journal of the Econometric Society* :1417–1426.

Nie, Huihua, Minjie Jiang, and Xianghong Wang. 2013. “The impact of political cycle: Evidence from coalmine accidents in China.” *Journal of Comparative Economics* 41 (4):995–1011.

Rawski, Thomas G. 2001. “What is happening to China’s GDP statistics?” *China Economic Review* 12 (4):347–354.

Revelli, Federico. 2003. “Reaction or interaction? Spatial process identification in multi-tiered government structures.” *Journal of Urban Economics* 53 (1):29–53.

———. 2006. “Performance rating and yardstick competition in social service provision.” *Journal of Public Economics* 90 (3):459–475.

Shen, Chunli, Jing Jin, and Heng-fu Zou. 2012. “Fiscal Decentralization in China: History, Impact, Challenges and Next Steps.” *Annals of Economics & Finance* 13 (1).

Shi, Min and Jakob Svensson. 2006. “Political budget cycles: Do they differ across countries and why?” *Journal of Public Economics* 90 (8):1367–1389.

Shirk, Susan L. 1993. *The political logic of economic reform in China*, vol. 24. University of California Press.

Shleifer, Andrei. 1985. "A theory of yardstick competition." *RAND Journal of Economics* :319–327.

Wallace, Jeremy. 2016. "Juking the stats? Authoritarian information problems in China." *British Journal of Political Science* 46 (01):11–29.

Wang, Shaoguang. 2006. "Regulating death at coalmines: changing mode of governance in China." *Journal of Contemporary China* 15 (46):1–30.

Wright, Tim. 2004. "The political economy of coal mine disasters in China: "your rice bowl or your life"." *The China Quarterly* 179:629–646.

Xu, Chenggang. 2011. "The fundamental institutions of China's reforms and development." *Journal of Economic Literature* 49 (4):1076–1151.

Yao, Yang and Muyang Zhang. 2015. "Subnational leaders and economic growth: evidence from Chinese cities." *Journal of Economic Growth* 20 (4):405–436.

Yu, Jihai, Li-An Zhou, and Guozhong Zhu. 2016. "Strategic interaction in political competition: evidence from spatial effects across Chinese cities." *Regional Science and Urban Economics* 57:23–37.

Zheng, Siqi, Matthew Kahn, Weizeng Sun, and Danglun Luo. 2014. "Incentives for China's urban mayors to mitigate pollution externalities: The role of the central government and public environmentalism." *Regional Science and Urban Economics* 47:61–71.

Zhuravskaya, Ekaterina. 2000. "Incentives to provide local public goods: fiscal federalism, Russian style." *Journal of Public Economics* 76 (3):337–368.

Appendix (Not For Publication)

A1 A Heuristic Model

Consider an environment with N agents, indexed as $i \in \{1, 2, ..., N\}$, and a principal, P. We can understand the agent as head of a city government, and the principal as his or her superior. Each agent chooses the level of coal mine deaths in city i, y_i. The agent's payoff consists of economic gains, which is mainly derived from coal mining sectors, and political reward, which is granted by the principal for keeping coal mining safe. Formally, the economic gain from the coal mining sector is a function of deaths in i and the deaths in its neighboring cities:

$$R_i = f(y_i, s\overline{y}_{-i}; \eta_i), \tag{A1}$$

where $\overline{y}_{-i} \equiv \sum_{j \neq i} y_j$ is the average level of deaths in cities other than i (i's neighbors). s is a parameter representing the magnitude of other cities' impact on economic gains through market interactions: larger s means more integrated markets or stronger spillovers. η_i is a vector of i's socioeconomic characteristics, such as the quality of coals, mining productivity, and the market power of coal mines in i. An improvement on coal mine safety (smaller y_i) is costly, as it requires cut-downs in production capacity and switching to safer and more expensive technologies. Hence, a reduction in y_i is associated with an decrease in R_i, the economic gain. We can interpret R_i as officials' personal rents from tolerating low safety conditions, or, simply the growth of local GDP. We assume that $\frac{\partial f}{\partial y_i} \equiv f_1 > 0$, and $\frac{\partial^2 f}{\partial y_i^2} \equiv f_{11} < 0$.

Neighbors' impact through market interactions is captured by $\frac{\partial f}{\partial (s\overline{y}_{-i})}$. A priori we do not commit to specific assumptions about the sign of market interactions. When competition effects dominates, an increase of deaths in neighbors is usually caused by production expansions, i's marginal economic gains should be negatively correlated with $\overline{y}_{-i}$: $\frac{\partial f}{\partial (s\overline{y}_{-i})} \equiv f_2 < 0$, and $\frac{\partial^2 f}{\partial y_i \partial (s\overline{y}_{-i})} \equiv f_{12} < 0$. If in the opposite, there is positive information spillovers in the market, coal mining companies can learn from neighbors how to acquire safety-enhancing technologies. i's (marginal) economic gain then is positively correlated with $\overline{y}_{-i}$: $f_2 > 0$ and $f_{12} > 0$. Political competition is implicitly modeled as the following.

$$G_i = g(y_i, \beta_P \overline{y}_{-i}; \eta_i, \psi_P), \tag{A2}$$

The principal uses the RPE as a base to determine political reward and punishment. The functional form of G_i follows the logic of Theorem 8 in Holmstrom (1982), which maintains that the principal can use the group-average as a reference for RPE in designing the optimal incentive scheme.[A1] We further assume that $\frac{\partial g}{\partial y_i} \equiv g_1 < 0$, $\frac{\partial^2 g}{\partial y_i^2} \equiv g_{11} \leq 0$, and $\frac{\partial^2 g}{\partial y_i \partial(\beta_P \overline{y}_{-i})} \equiv g_{12} > 0$. That is, an improvement of coal mine safety in i's neighbors increases the political stake of coal mine safety for i. Intuitively, agents exert more efforts to catch up when they fall behind. The intensity of the RPE is captured by $\beta_P \geq 0$, which is set by the principal. Larger β_P suggests that each agent receives more severe punishments when scoring lower on safety. η_i is a vector of cities' political characteristics, and ψ_P is a vector of the principal's characteristics.

The utility function of agent i, u_i, is the weighted average between economic and political gains:

$$u_i = \alpha_i R_i + (1 - \alpha_i) G_i = \alpha_i f(y_i, s\overline{y}_{-i}; \eta_i) + (1 - \alpha_i) g(y_i, \beta_P \overline{y}_{-i}; \eta_i, \psi_P), \tag{A3}$$

where α_i is the weight agent i assigns to the economic gain, and $1 - \alpha_i$ is the weight assigned to the political gain. α_i depends on a set of characteristics of cities and local leaders. The agent's problem is to choose y_i, to maximize u_i, taking into consideration the tradeoff between the economic and political gains with y_i. The principal faces a similar growth-versus-safety tradeoff and thus has an optimal target for the average level of disaster of all N agents, $\hat{y}$. The principal intends to set the overall safety condition of all cities, $\bar{y} = \frac{1}{N} \sum_i y_i$, to achieve this target. Formally, the principal's utility can be represented by the following quadratic loss function:

$$u_P = -(\overline{y} - \hat{y})^2. \tag{A4}$$

[A1] Here, the trade-off between competition on GDP growth and political gains associated with coal mine safety is implicitly modeled as the substitution between R_i (economic gain) and G_i (political gain). For local leaders, the incentive of engaging in the competition on GDP growth is pivotal and well-established in the literature, and thus one can justifiably model local leaders as GDP or rent-maximizer, with growth or rent being determined by its own efforts and those of the neighbors: $R_i = f(y_i, s\overline{y}_{-i}; \eta_i)$. Conceptually, one can always add a third term to capture the contribution of GDP growth to political promotions. Yet the current setting can be easily adapted to account for the competition on GDP growth, say, by assuming that gain is proportional to R_i.

When all agents take the principal's incentive scheme as given ajnd simultaneously decide their y_i, i's best-reply is implicitly determined by the first order condition for maximizing u_i:

$$y_i^* = h(\overline{y}_{-i}; s, \alpha_i, \beta_P, \eta_i, \psi_P)^{\text{A2}}. \tag{A5}$$

Employing the implicit function theorem, we can obtain the slope of i's best-reply function as:

$$\frac{\mathrm{d}y_i^*}{\mathrm{d}\overline{y}_{-i}} = \frac{-\alpha_i f_{12} s - (1-\alpha_i) g_{12} \beta_P}{\alpha_i f_{11} + (1-\alpha_i) g_{11}} \equiv \beta. \tag{A6}$$

The neighborhood effect is captured by the slope of the best-reply, β. The denominator of β is negative as $f_{11} < 0$ and $g_{11} \leq 0$. For analytical convenience we assume that $g_{11} = 0$[A3]. The expression of neighborhood effect is then reduced to $\beta \equiv -s\frac{f_{12}}{f_{11}} - \frac{(1-\alpha_i)g_{12}\beta_P}{\alpha_i f_{11}}$. The first term, $-s\frac{f_{12}}{f_{11}}$, is the neighborhood effect due to the market interactions. It is positive if $f_{12} > 0$, and negative if otherwise. The second term, $-\frac{(1-\alpha_i)g_{12}\beta_P}{\alpha_i f_{11}}$, is the neighborhood effect due to the RPE. It is positive because $g_{12} > 0$ and $f_{11} < 0$. Note that β_P and α_i affect the neighborhood effect only through the channel of the RPE. Further inspection shows that $\frac{\partial \beta}{\partial \beta_P} = -\frac{(1-\alpha_i)g_{12}}{\alpha_i f_{11}} > 0$ and $\frac{\partial \beta}{\partial \alpha_i} = \frac{g_{12}\beta_P}{\alpha_i^2 f_{11}} < 0$. The results can be summarized as follows.

Claim 1 *The neighborhood effect can be decomposed into two parts: the RPE effect, which is always positive, and the market interaction effect, which is positive (negative) when $f_{12} > 0$ (when $f_{12} < 0$).*

Claim 2 *When the neighborhood effect is positive, the effect for city i is stronger when the RPE is more intensively used (larger β_P) and when the agent assigns a smaller weight to the economic gains (smaller α_i).*

Because the market interaction effect can be either positive or negative, the sign of the neighborhood effect is not determined. We do know, as Claim 2 suggests, that the overall neighborhood effect is positive when the RPE effect dominates the market interaction effects. When the market interaction effect dominates, the neighborhood effect is stronger among neighbors with more integrated markets if $f_{12} > 0$, and becomes weaker with more integrated markets if $f_{12} < 0$. This implication is readily testable through estimating neighborhood effects using different radius to define the size of neighborhood

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[A2] The second order condition holds given the assumptions on the signs of partial derivatives of f and g.

[A3] A number of functional forms meet this requirement. For example, $g = x_i(B - \beta_P \overline{x}_{-i})$, where B is a constant.

effect. The results presented in Table 3 show that the estimates do not vary much along with changing size of neighborhood, and the effect is almost non-existing among geographically proximate cities in other provinces. Thus, the neighborhood effect mainly comes out of the RPE effect, rather than market interactions.

The principal's problem is to choose β_P to maximize u_P. To keep the intuition simple, we assume that $\alpha_i = \overline{\alpha}$, $\eta_i = \overline{\eta}$. Thus in the (symmetric) equilibrium the level of coal mine deaths is the same for each i: $y_i^* = \overline{y}^*$. The Nash equilibrium y_i^* ($\forall i \in 1, 2, ..., N$) solves $\overline{\alpha} f_1(\overline{y}^*, s\overline{y}^*; \overline{\eta}) + (1-\overline{\alpha}) g_1'(\overline{y}^*, \beta_P \overline{y}^*; \overline{\eta}, \psi_P) = 0$. The principal then simply chooses β_P^* to induce her optimal level of disaster, $\hat{y} (= y_i^* = \overline{y}^*)$. We can then write the principal's choice β_P^* as a function of her ideal $\hat{y}$. Applying the implicit function theorem to the first order condition of principal's maximization problem and using $g_{11} = 0$, we obtain that:

$$\frac{\partial \beta_P^*}{\partial \hat{y}} = -\frac{\hat{y} g_{12}(1-\overline{\alpha})}{\overline{\alpha}(f_{11} + s f_{12}) + (1-\overline{\alpha}) \beta_P^* g_{12}} \tag{A7}$$

In Equation (A7), the numerator of the right hand side is positive. The sign of denominator depends on $\overline{\alpha}$, f_{11}, f_{12}, and g_{12}. It is easy to see that, when $s f_{12} > -f_{11} + \beta_P g_{12} > 0$, the denominator is positive and hence the overall sign of $\frac{\partial \beta_P^*}{\partial \hat{y}}$ is negative. When $s f_{12} < -f_{11} + \beta_P g_{12}$, the denominator is positive as $\overline{\alpha}$ is relatively small: $\overline{\alpha} < \frac{\beta_P^* g_{12}}{-f_{11} - s f_{12} + \beta_P^* g_{12}} \in (0, 1)$, and the overall sign of $\frac{\partial \beta_P^*}{\partial \hat{y}}$ is negative. When $\overline{\alpha}$ is relatively large, by contrast, the denominator can be negative and $\frac{\partial \beta_P^*}{\partial \hat{y}}$ can be positive.

Claim 3 *A positive neighborhood effect tends to be stronger when the principal has a higher target of coal mine safety, or* $\frac{\partial \beta_P^*}{\partial \hat{y}} < 0$*, as long as the market interaction effect is positive and sufficiently large:* $s f_{12} > -f_{11} + \beta_P g_{12}$*, or when agents attach enough importance over the coal mine disaster:* $\overline{\alpha} < \frac{\beta_P^* g_{12}}{-f_{11} - s f_{12} + \beta_P^* g_{12}}$*. Together with Claim 2 we have* $\frac{\partial \beta}{\partial \hat{y}} < 0$.

Claim 3 establishes a theoretical link between the size of neighborhood effect and the principal's ideal goal of coal mine safety. Because the safety performance in a city affects the utilities of its neighbors, the Nash equilibrium are generally suboptimal given strategic complementarities among agents. However, the principal is able to alleviate efficiency loss by adjusting β_P. Specifically, a larger β_P set by the principal is simultaneously associated with stronger interactions and a lower level of deaths provided that the market interaction effect is positive and sufficiently large (large f_{12}), or, when city officials' care for political reward is sufficiently large (small α_i). These implications are tested in Section 5.6 and 5.7.

A2 A Note on QML Estimation

This section illustrates the logic of Quasi-maximum likelihood estimation used in the empirical analysis, with some notations mechanically following the method developed by Lee and Yu (2010). The baseline specification of Equation (1) in section 4 is a spatial autoregressive (SAR) model:

$$Y_{Nt} = W_N Y_{Nt} \cdot \beta + X_{Nt}\theta + c_{N0} + \alpha_{t0} l_N + V_{Nt}, t = 1, 2, ..., T. \tag{A8}$$

where $Y_{NT} = (y_{1t}, y_{2t}, ..., y_{Nt})'$ is the matrix form of the dependent variable. W_N is an $N \times N$ spatial weighting matrix, which depicts the proximity of each pair of cities. X_{Nt} is an $N \times K$ matrix of regressors, including the control variables and province-specific time trends and political cycles. c_{N0} is an $N \times 1$ vector of city fixed effects, l_N is an $N \times 1$ vector of ones, and $\alpha_{t0} l_N$ is a $N \times 1$ vector of quarter fixed effects. $V_{Nt} = (\epsilon_{1t}, \epsilon_{2t}, ..., \epsilon_{Nt})$ is the vector for random disturbances, which are i.i.d. with mean zero and variance σ^2. β is the coefficient for spatial autocorrelation, or the neighborhood effects, of coal mine deaths.

Even if we assume that equation (A8) represents the true model of the data generating process (in the sense that there is no omitted variable), naively running the linear panel regression of equation (A8) results in simultaneity bias (or "reflection bias"), since by construction $\text{cov}(W_N Y_{Nt}, V_{Nt}) \neq 0$. Quasi-maximum likelihood estimation can take care of this problem, since it is based on optimizing the likelihood function that fully exploits the information (especially $\text{cov}(W_N Y_{Nt}, V_{Nt}) \neq 0$) of the data generating process. In our context, the procedure of the estimation is as follows.

The first step is to eliminate the individual and time fixed effects. We use the transformation method in Lee and Yu (2010) to avoid creating time interdependence of the disturbance terms. Let $[F_{T,T-1}, \frac{1}{\sqrt{T}} l_T]$ be the orthonormal eigenvector matrix of $J_T = I_T - \frac{1}{T} l_T l_T'$, so $F_{T,T-1}$ is the submatrix corresponding to the eigenvalues of one. Left-multiplying $F_{T,T-1}$ to equation (A8) yields

$$Y_{Nt}^{*} = W_N Y_{Nt}^{*}\beta + X_{Nt}^{*}\theta + F_{T,T-1}\alpha_{t0} l_N + V_{Nt}^{*}, \tag{A9}$$

where $Y_{Nt}^{*} = F_{T,T-1}Y_{Nt}$, $X_{Nt}^{*} = F_{T,T-1}X_{Nt}$, $V_{Nt}^{*} = F_{T,T-1}V_{Nt}$, and $F_{T,T-1}c_{N0} = 0$. Hence individual fixed effects are eliminated. Similarly, let $[F_{N,N-1}, \frac{1}{\sqrt{N}} l_N]$ be the orthonormal eigenvector matrix of $J_N = I_N - \frac{1}{N} l_N l_N'$, where $F_{N,N-1}$ is the submatrix corresponding to the eigenvalues of one. Left-multiplying $F_{N,N-1}$ to equation (A9) yields

$$Y_{Nt}^{**} = W_N Y_{Nt}^{**}\beta + X_{Nt}^{**}\theta + V_{Nt}^{**}, \tag{A10}$$

and the time fixed effects cancel out of the equation. By this transformation approach, we have $E(V_{1t}^{**}, ..., V_{Nt}^{**})(V_{1t}^{**}, ..., V_{Nt}^{**})' = \sigma^2 I_{T-1} \bigotimes I_{N-1}$. Hence elements in V_{it}^{**} are uncorrelated in the dimension of N and T.

Second, derive and optimize the likelihood function. Define $S_N(\beta) = I_N - \beta W_N$, we can derive the "reduced form" equation from (A10):

$$Y_{Nt}^{**} = S_N^{-1}(\beta) X_{Nt}^{**}\theta + S_N^{-1}(\beta) V_{Nt}^{**}, \tag{A11}$$

In equation (A11), all right-hand-side regressors are exogenous. In this way the simultaneity bias is solved. Yet since the RHS is a non-linear function of the unknown parameter β, we cannot use linear regression to estimate it. Instead, given that elements in V_{it}^{**} are i.i.d with normal distribution, we can derive the log-likelihood function given equation (A11). Define $\phi = (\beta, \theta, \sigma^2)$, the log-likelihood is

$$\begin{aligned} \ln L_{NT}(\phi) = -\frac{(N-1)(T-1)}{2}\ln(2\pi\sigma^2) - (T-1)[\ln(1-\beta) - \ln(|S_N(\beta)|)] \\ -\frac{1}{2\sigma^2}\sum_{t=1}^{T} \tilde{V}_{Nt} J_N \tilde{V}_{Nt}' \end{aligned} \tag{A12}$$

where $\tilde{V}_{Nt} = S_N^{-1}(\beta) Y_{Nt}^{**} - X_{Nt}^{**}\theta$, and $J_N = I_N - \frac{1}{N} l_N l_N'$. Taking the first- and second-order derivatives of $\ln L_{NT}(\phi)$ yields the estimates of the parameter of interest. The detail of the algebraic operations is available in the Appendix C of Lee and Yu (2010). Also, Lee and Yu (2010) show that the estimates have some good properties such as consistency (as N and T are large) and asymptotic normality.

A3 Tables in Appendix

Table A1: City Selection

Province	City	Province	City	Province	City
Hebei	Shijiazhuang	Anhui	Wuhu	Hunan	Yiyang
Hebei	Tangshan	Anhui	Huainan	Hunan	Chenzhou
Hebei	Qinhuangdao	Anhui	Huaibei	Hunan	Yongzhou
Hebei	Handan	Anhui	Tongling	Hunan	Huaihua
Hebei	Xingtai	Anhui	Anqing	Hunan	Loudi
Hebei	Baoding	Anhui	Fuyang	Sichuan	Chengdu
Hebei	Zhangjiakou	Anhui	Suzhou	Sichuan	Zigong
Hebei	Chengde	Anhui	Bozhou	Sichuan	Panzhihua
Shanxi	Taiyuan	Anhui	Chizhou	Sichuan	Luzhou
Shanxi	Datong	Anhui	Xuancheng	Sichuan	Deyang
Shanxi	Yangquan	Fujian	Sanming	Sichuan	Mianyang
Shanxi	Changzhi	Fujian	Quanzhou	Sichuan	Guangyuan
Shanxi	Jincheng	Fujian	Nanping	Sichuan	Neijiang
Shanxi	Shuozhou	Fujian	Longyan	Sichuan	Leshan
Shanxi	Jinzhong	Jiangxi	Nanchang	Sichuan	Meishan
Shanxi	Yuncheng	Jiangxi	Jingdezhen	Sichuan	Yibin
Shanxi	Xinzhou	Jiangxi	Pingxiang	Sichuan	Guang’an
Shanxi	Linfen	Jiangxi	Jiujiang	Sichuan	Dazhou
Shanxi	Lüliang	Jiangxi	Xinyu	Sichuan	Ya’an
Inner Mongolia	Hohhot	Jiangxi	Ganzhou	Sichuan	Bazhong
Inner Mongolia	Baotou	Jiangxi	Ji’an	Guizhou	Guiyang
Inner Mongolia	Wuhai	Jiangxi	Yichun	Guizhou	Liupanshui
Inner Mongolia	Chifeng	Jiangxi	Fuzhou	Guizhou	Zunyi
Inner Mongolia	Tongliao	Jiangxi	Shangrao	Guizhou	Anshun
Inner Mongolia	Ordos	Shandong	Jinan	Yunnan	Kunming
Inner Mongolia	Hulunbuir	Shandong	Zibo	Yunnan	Qujing
Inner Mongolia	Bayannur	Shandong	Zaozhuang	Yunnan	Yuxi
Liaoning	Shenyang	Shandong	Jining	Yunnan	Zhaotong
Liaoning	Fushun	Shandong	Tai’an	Yunnan	Lijiang
Liaoning	Benxi	Shandong	Linyi	Yunnan	Lincang
Liaoning	Dandong	Henan	Zhengzhou	Shaanxi	Tongchuan
Liaoning	Jinzhou	Henan	Luoyang	Shaanxi	Baoji
Liaoning	Fuxin	Henan	Pingdingshan	Shaanxi	Xianyang
Liaoning	Liaoyang	Henan	Anyang	Shaanxi	Weinan
Liaoning	Tieling	Henan	Hebi	Shaanxi	Yan’an
Liaoning	Chaoyang	Henan	Xinxiang	Shaanxi	Hanzhong
Liaoning	Huludao	Henan	Jiaozuo	Shaanxi	Yulin
Jilin	Changchun	Henan	Xuchang	Shaanxi	Ankang
Jilin	Jilin	Henan	Luohe	Shaanxi	Shangluo
Jilin	Siping	Henan	Sanmenxia	Gansu	Lanzhou
Jilin	Liaoyuan	Henan	Nanyang	Gansu	Jinchang
Jilin	Tonghua	Henan	Shangqiu	Gansu	Baiyin
Jilin	Baishan	Hubei	Huangshi	Gansu	Wuwei
Jilin	Baicheng	Hubei	Shiyan	Gansu	Zhangye
Heilongjiang	Harbin	Hubei	Yichang	Gansu	Pingliang
Heilongjiang	Jixi	Hubei	Jingmen	Gansu	Jiuquan
Heilongjiang	Hegang	Hubei	Jingzhou	Gansu	Qingyang
Heilongjiang	Shuangyashan	Hubei	Xianning	Gansu	Longnan
Heilongjiang	Jiamusi	Hunan	Changsha	Ningxia	Yinchuan
Heilongjiang	Qitaihe	Hunan	Zhuzhou	Ningxia	Shizuishan
Heilongjiang	Mudanjiang	Hunan	Xiangtan	Ningxia	Wuzhong
Heilongjiang	Heihe	Hunan	Hengyang	Ningxia	Guyuan
Jiangsu	Xuzhou	Hunan	Shaoyang	Ningxia	Zhongwei
Jiangsu	Lianyungang	Hunan	Changde		
Jiangsu	Yancheng	Hunan	Zhangjiajie		

Table A2: Baseline Results: Same Province, 250km

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: log(1+ # of Coalmine Deaths)					
		QMLE			OLS	
Avg log(1+ Deaths), Same Province 250km	0.318***	0.321***	0.261***			
	(0.043)	(0.041)	(0.036)			
lag log(1+ Deaths)				0.074***	0.077***	0.063***
				(0.019)	(0.019)	(0.0209)
lag Avg log(1+ Deaths), Same Province 250km				0.127***	0.149***	0.115**
				(0.032)	(0.032)	(0.052)
Spatial Standard Error(200km)				[0.025]***	[0.025]***	[0.045]**
Spatial Standard Error(250km)				[0.025]***	[0.026]***	[0.045]**
Spatial Standard Error(250km)				[0.025]***	[0.026]***	[0.046]**
Control Variables	Y	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y	Y
Year-Quarter FE	Y	Y	Y	Y	Y	Y
Province-Quarter Time Trends	Y	Y	Y	Y	Y	Y
Provincial Political Cycles	N	Y	Y	N	Y	Y
Province-Quarter FE	N	N	Y	N	N	Y
R-squared	0.242	0.254	0.377	0.233	0.238	0.346
Number of Cities	163	163	163	163	163	163
Observations	7172	7172	7172	7009	7009	7009

Note: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. Controls include own and neighbors' average log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial government. Standard errors reported in parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table A3: Robustness Checks Using Other Functions of Deaths

Panel A: Inverse Hyperbolic Sine of # of Coal Mine Deaths

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	DV: Inverse Sine of # of Coal Mine Deaths						
	Cities in the Same Province				Cities in Other Provinces		
	200 km	250 km	300 km	All	200 km	250 km	300 km
lag Neighbor Avg. Inverse Sine of # of Coal Mine Deaths	0.126***	0.153***	0.174***	0.190***	0.0192	-0.0183	-0.0451
	(0.0298)	(0.0312)	(0.0339)	(0.0372)	(0.0251)	(0.0276)	(0.0325)
lag Inverse Sine of # of Coal Mine Deaths	0.0803***	0.0789***	0.0772***	0.0756***	0.0851***	0.0858***	0.0862***
	(0.0186)	(0.0187)	(0.0188)	(0.0188)	(0.0190)	(0.0192)	(0.0192)
Spatial S.E. (200km)	[0.024]***	[0.024]***	[0.024]***	[0.024]***	[0.020]	[0.021]	[0.026]
Spatial S.E. (250km)	[0.025]***	[0.025]***	[0.025]***	[0.025]***	[0.021]	[0.022]	[0.026]
Spatial S.E. (300km)	[0.025]***	[0.025]***	[0.025]***	[0.025]***	[0.021]	[0.022]	[0.026]
Observations	7,009	7,009	7,009	7,009	7,009	7,009	7,009
R-squared	0.254	0.256	0.256	0.256	0.253	0.252	0.252
Number of Cities	163	163	163	163	163	163	163

Panel B: Coal Mine Deaths Normalized By Production

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent Variable: log(1+ # of Coal Mine Deaths/Coal Production)						
	Cities in the Same Province				Cities in Other Provinces		
	200 km	250 km	300 km	All	200 km	250 km	300 km
lag Neighbor Avg. log(1+ # of Coal Mine Deaths/Coal Production)	0.101***	0.132***	0.149***	0.178***	0.0205	-0.00757	0.038
	(0.0282)	(0.0318)	(0.0327)	(0.0379)	(0.0253)	(0.0336)	(0.048)
lag log(1+ # of Coal Mine Deaths/Coal Production)	0.0921***	0.0910***	0.0906***	0.0889***	0.0948***	0.0940***	0.0949***
	(0.0230)	(0.0230)	(0.0231)	(0.0230)	(0.0231)	(0.0232)	(0.0232)
Spatial S.E. (200km)	[0.024]***	[0.024]***	[0.024]***	[0.024]***	[0.020]	[0.021]	[0.026]
Spatial S.E. (250km)	[0.025]***	[0.025]***	[0.025]***	[0.025]***	[0.021]	[0.022]	[0.026]
Spatial S.E. (300km)	[0.025]***	[0.025]***	[0.025]***	[0.025]***	[0.021]	[0.022]	[0.026]
Observations	7,009	7,009	7,009	7,009	7,009	7,009	7,009
R-squared	0.200	0.201	0.201	0.202	0.198	0.199	0.198
Number of Cities	163	163	163	163	163	163	163

Note: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial government. Standard errors reported in parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table A4: Neighbors Defined By Economic Similarity

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: log(1+ Deaths)					
		QMLE			OLS	
Avg. log(1+ # Coal Mine Deaths), Same Province Weighted	0.329***	0.332***	0.273***			
	(0.043)	(0.042)	(0.038)			
log(1+ # lag Coal Mine Deaths)				0.055***	0.056***	0.042**
				(0.014)	(0.014)	(0.016)
lag Avg. log(1+ # Coal Mine Deaths), Same Province Weighted				0.137***	0.147***	0.071
				(0.037)	(0.037)	(0.069)
Spatial Standard Error(200km)				[0.030]***	[0.031]***	[0.060]
Spatial Standard Error(250km)				[0.031]***	[0.031]***	[0.060]
Spatial Standard Error(300km)				[0.031]***	[0.031]***	[0.061]
Control Variables	Y	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y	Y
Quarter FE	Y	Y	Y	Y	Y	Y
Provincial Time Trends	Y	Y	-	Y	Y	-
Provincial Political Cycles	N	Y	-	N	Y	-
Province-Year-Quarter FE	N	N	Y	N	N	Y
Observations	7172	7172	7172	7,009	7,009	7,009
R-squared	0.254	0.265	0.383	0.167	0.170	0.280
Number of Cities	163	163	163	163	163	163

Note: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. For city i, the neighbor j's weight is given by $\omega_{ij} = \frac{1(j \in P_i)|GDP_{i,2001} - GDP_{j,2001}|^{-1}}{\sum_k [1(k \in P_i)|GDP_{i,2001} - GDP_{k,2001}|^{-1}]}$, where $1(j \in P_i)$ is a dummy indicating whether j is in i's province P_i, and $GDP_{i,2001}$ is city i's per capita GDP in 2001. ω_{ij} assigns more weights to cities with similar per capita GDP. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial government. Standard errors reported in the parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table A5: Capital Cities and Sub-provincial Cities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				log(1+ Deaths)				
	200km	250km	300km	All	200km	250km	300km	All
Avg. Neighbors' log(1+ Deaths)	0.122***	0.147***	0.168***	0.184***	0.123***	0.151***	0.175***	0.190***
	(0.0314)	(0.0328)	(0.0357)	(0.0404)	(0.0328)	(0.0339)	(0.0364)	(0.0412)
lag log(1+ Deaths)	0.0770***	0.0757***	0.0738***	0.0732***	0.0775***	0.0765***	0.0744***	0.0735***
	(0.0188)	(0.0189)	(0.0189)	(0.0189)	(0.0188)	(0.0188)	(0.0189)	(0.0189)
Avg. Neighbors' log(1+ Deaths) *1(Capital City)	0.136	0.158	0.137	0.0897				
	(0.199)	(0.131)	(0.128)	(0.126)				
Avg. Neighbors' log(1+ Deaths) *1(Subprovincial City)					0.0202	-0.0114	-0.0225	-0.0211
					(0.0770)	(0.0853)	(0.0912)	(0.0904)
R-squared	0.237	0.238	0.238	0.237	0.236	0.238	0.238	0.237
Number of Cities	163	163	163	163	163	163	163	163
Observations	7,009	7,009	7,009	7,009	7,009	7,009	7,009	7,009

Note: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial government. Standard errors reported in parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table A6: The Dynamics of Neighborhood Effects - Robustness Check

	(1)	(2)	(3)
	Dependent Variable: log(1+ Deaths)		
	Full Sample	In the Same Year	Not in the Same Year
lag log(1+ Deaths)	0.0762***	0.127***	0.0295
	(0.0192)	(0.0243)	(0.0269)
lag Avg. Neighbors' log(1+ Deaths), Same Province All	0.160***	0.216***	0.124**
	(0.0414)	(0.0598)	(0.0501)
lag 2 Avg. Neighbors' log(1+ Deaths), Same Province All	0.0482	0.0554	0.0327
	(0.0349)	(0.0507)	(0.0485)
Observations	6,846	3,586	3,260
R-squared	0.246	0.265	0.236
Number of Cities	163	163	163

Note: The sample covers 163 coal producing cities and 44 quarters from 2001 to 2011. In all columns, city and year-quarter fixed effects, provincial time trends, and province-political cycles are included. Controls include own and neighbors' average log real GDP per capita, own and neighbors' average log coal production, percentage share of secondary industry, log population density, log freight transport, and the number of laws regarding coal mine safety enacted by the provincial government. Standard errors reported in parentheses are clustered at the city level. Spatial standard errors of the estimates for neighbors' average deaths are reported in brackets (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.