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The Case of Chinese Coal Mine Safety

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September 24, 2016

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JEL Classification: D73, H77, L51

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1 Introduction

The social science literature has long entertained the idea of neighborhood effects, namely individuals from the same group (the "neighborhood") exhibit correlated behaviors. Neighborhood is often defined on the social space or according to the peer group, in which social interactions drive individual choices, such as participation in welfare programs (Bertrand, Luttmer, and Mullainathan, 2000; Luttmer, 2001; Aizer and Currie, 2004), adoption of new technologies (Conley and Udry, 2001; Conley and Udry, 2010), occupational choices (Borjas and Hilton, 1996; Bayer, Ross, and Topa, 2008), schooling (Evans, Oates, and Schwab, 1992; De Giorgi and Pellizzari, 2014), and crimes (Glaeser, Sacerdote, and Scheinkman, 1996; Calvó-Armengol and Zenou, 2004).

Beyond individual choices, neighborhood effects are also present in politics, in which the neighborhood can be defined according to political jurisdictions. Yardstick competition among politicians induces a correlation of economic policies when voters use inter-jurisdictional comparison to evaluate incumbents (Besley and Case, 1995, Bordignon, Cerniglia, and Revelli, 2003). Policymakers also learn from experimentations by neighboring jurisdictions and imitate (Fredriksson and Millimet, 2002; Shipan and Volden, 2006). Political neighborhood effects can arise from many different channels, such as information sharing, reaction to common shocks, and strategic interactions in political competition. In turn, the mechanisms behind political neighborhood effects depend on specific institutions that shape the incentive structure of agents.

In this paper, we argue that strategic competition under the relative performance evaluation (RPE) can be a key mechanism leading to neighborhood effects. We empirically investigate the coal mine safety in Chinese cities to illustrate this point. The institutional structure of China underlies an essential place of the neighborhood effects in driving behaviors of local governments. City officials are evaluated, supervised, and appointed by provincial superiors, and for this reason we consider the province as the political neighborhood of cities. The current bureaucratic system is decentralized to the extent that local governments are self-contained units with autonomy over a wide range of policy issues. Local officials face similar tasks of allocating government resources and implementing policies set by the superiors. This feature of the "M-form" organization implies that performance comparison among jurisdictions is able to elicit credible information about agents' efforts (Maskin, Qian, and Xu, 2000). In turn, the RPE is used as an essential mechanism for the political selection in the Party's cadre system (Li and Zhou, 2005; Xu, 2011). Under this system, local officials are signed into a competition for upper level positions, where the chances of winning are determined by relative performance in the same political neighborhood. Neighborhood effects thus emerge when local officials' policy choices are conditioned upon their neighbors' performances.

We investigate how coal mine deaths at the city level are affected by neighbors' safety performances in the period between 2001 and 2011, when the central government began to promote coal mine safety through regulatory overhauls. Before the 2000s, coal mine safety was a secondary issue for local governments despite notoriously high deathrates. It was because the enforcement of safety regulations had negative impacts on economic gains of local governments, and yet the political returns from improving safety were hardly commensurate with the economic losses (Wright, 2004; Wang, 2006). However, local governments are induced to exert more efforts on regulation when safety is valued by the principal so that the political rewards of maintaining safety suffice to offset the economic losses. The stake of coal mine safety dramatically increased after several severe disasters in the early 2000s, and since then coal mine safety has become a high profile problem. The central government implemented a set of reforms in response to the public infuriation over rampant deaths. The State Administration of Workplace Safety was upgraded and empowered to monitor local governments and coal mines. The State Council passed rules of sanction to assure that local officials are accountable for disasters[1]. But most importantly, the central government motivates the efforts of local governments through personnel control. We argue that these reforms translate into strong neighborhood effects with regard to coal mine deaths.

[1]The State Council is the administrative organ presided by the premier. The State Administration of Workplace Safety is a ministerial level agency responsible for workplace safety under the jurisdiction of the State Council.

We propose a simple analytical framework to clarify the theoretical mechanisms fostering the neighborhood effects. We model the level of coal mine safety as a choice by local governments, which is affected by the neighbors' strategies through both market interactions and political competition. Coal mining firms in different (especially geographically adjacent) cities interact with one another in the market, and their profitabilities are thus interrelated. Furthermore, since (1) safety regulation enforced by a city government greatly affects the production costs of the coal mining firms (and hence their profitabilities), and (2) these firms contribute significantly to local economy, the economic gains of the local government are influenced by the regulatory policies of all cities in the same political neighborhood. The competition on safety, on the other hand, is a key factor in determining political promotion. When safety levels increase in a city's political neighbors (cities in the same province), the marginal return of improving the city's own safety also increases. Falling behind on safety reduces the probability of promotion for the city officials, and hence forces the city government to raise its own safety level. This political competition under RPE implies a positive spatial correlation in the same political neighborhood, the province. Our empirical tests hinge on this hypothesis.

A primary challenge to identification is the simultaneity bias: neighbors exert mutual influences, and hence the estimation for neighborhood interaction is compromised by the "reflection problem" (Manski, 1993). We adopt two approaches to deal with the simultaneity bias. First, we use the one-period lag of neighbors' deaths as the explanatory variable and estimate a dynamic model (Fredriksson and Millimet, 2002; Aizer and Currie, 2004; Munshi, 2004). Second, we estimate a spatial autoregressive (SAR) model with time and cross-section fixed effects, using the quasi-maximum likelihood estimation (QMLE) proposed by Lee and Yu (2010) to solve the endogeneity problem due to spatial interdependence and the incidental parameter problem raised by fixed effects.

Our baseline results attest to strong neighborhood effects. The estimates of the neighborhood effects are stable when adopting different geographical distances to define political neighbors within the same province. The effects cease to exist for geographical neighbors located in different provinces. Because RPE or promotion competition occurs only among cities in the same province, while market interactions exist beyond provincial boundaries, we attribute the neighborhood effects to the political competition rather than the market interactions.

In addition to the simultaneity bias, the estimation of the neighborhood effects may be subject to the omitted variable bias. The spatial correlation may result from a common response to contextual factors rather than strategic interaction (Manski, 2000). We employ several tests to determine whether contextual interaction, rather than strategic interaction, drives the neighborhood effects. We use higher-order time lags of neighbors' deaths to estimate the neighborhood effects. If city governments merely react to policy changes initiated from above, they should (correctly) anticipate the persistent intensification of regulations. Hence the effects should be stable over a relatively long time span. We do not find any neighborhood effect beyond two-quarter lags.

We also address the possibility that the estimates for the neighborhood effects are biased due to report manipulation. To this end, we employ deaths in the first three quarters, cities' distances to their provincial capital, and road traffic accidental deaths, to implement falsification tests. Some recent works by economists and political scientists raise the concern about the quality of official data in China (Fisman and Wang, 2016; Wallace, 2016). The purpose of these tests is not to detect the manipulation per se, but to determine whether our estimates are biased by correlated report manipulations across cities. The tests respectively take account of the prevalence of manipulation near the end of year, the agency cost of supervising city governments, and the possibility that manipulation exists in all types of accidents. Opposite to what the logic of report manipulation may imply, the results suggest that our estimates are unlikely to have been inflated by manipulation even if it may nevertheless exist.

We further examine region heterogeneity in the neighborhood effects through a set of difference-in-difference tests. The theoretical framework we propose predicts that the magnitude of the neighborhood effects is larger when safety is a priority in the political environment. Consistent with this premise, we find that the neighborhood effects appear to be larger (1) after the central government implemented comprehensive reforms in attempt to promote the coal mine safety in 2005, (2) when the meetings of National Party's Congress are approaching, (3) when the age of provincial party secretaries presiding the cities implies strong promotion incentives, (4) and when cities rank relatively high on GDP growth and low on coal mine safety. Altogether, the results show that regional competition under the RPE is instrumental in promoting governments' performances even for policy issues conceived as "second-dimensional".

The remainder of this paper is organized as follows. Section 2 discusses the relevant literature. Section 3 proposes the theoretical framework for understanding the neighborhood effects under the RPE. Section 4 introduces the institutional background. Section 5 describes the data. Section 6 discusses the identification strategy. Section 7 reports the empirical results. Section 8 concludes the paper.

2 Relation to the Literature

Previous literature offers a variety of theoretical explanations for neighborhood effects. Individuals have other-regarding preferences that help them to mutually engage in pro-social behaviors such as voting and charity giving (Becker, 1974; Edlin, Gelman, and Kaplan, 2007). Individuals in the same peer group imitate each other in shirking, crimes, and welfare participation (Moffitt, 1983; Kandel and Lazear, 1992; Glaeser, Sacerdote, and Scheinkman, 1996; Rasmusen, 1996; Luttmer, 2001). Choices may transmit because of information spillovers (Aizer and Currie, 2004; Bayer, Ross, and Topa, 2008). All these explanations maintain that individuals strategically take others' behaviors into account, characterized by Manski (2000) as "endogenous interaction."

By a similar token, our explanation for neighborhood effects in coal mine deaths posits the endogenous interaction. But differently, we argue that political competition under RPE is a primary channel of the interaction. The logic of the RPE applies generically to centralized organizations, such as firms or bureaucratic systems. Lazear and Rosen (1981) show that when agents are risk averse, compensation schemes based on ordinal ranks can be optimal. Holmstrom (1982) studies the incentive problem in team production in the presence of moral hazard. He shows that when the productivity shocks are correlated across individuals, the optimal incentive schemes should take account of the weighted average of individual performances. These incentive schemes provide a ground for strategic competition, which in turn gives rise to the neighborhood effects.

The models on tournament competition and the RPE motivate a fruitful literature on the political economy in China (Li and Zhou, 2005; Lü and Landry, 2014; Yu, Zhou, and Zhu, 2016). Our paper follows this path to study how competition for promotion drives government performance. As Xu (2011) argues, local officials have autonomy over a wide range of policies. Meanwhile, the relative performance evaluation is critical for career advancements. In turn, regional competition occurs on many issues from investment solicitation to revenue collection. We divert from the conventional focus on economic or fiscal competition to examine a seemingly secondary issue, the coal mine safety. The mounting deaths called into question political legitimacy, making it a compelling case to restore the public confidence government capability. Thus, the stake of coal mine safety became sufficiently high for the ruling Party. The logic also applies to other "second-dimensional" issues from environmental regulation to food safety (Markusen, Morey, and Olewiler, 1995; Fredriksson and Millimet, 2002; Wright, 2004; List, Strum, and Sturm, 2006; Wang, 2006;).

Our paper is related to a large literature on inter-government interactions. Fiscal competition under political decentralization is often proposed as a mechanism of inter-jurisdictional policy convergence (Brueckner, 1998; Figlio, Kolpin, and Reid, 1999; Saavedra, 2000; Brueckner and Saavedra, 2001; Solé-Ollé, 2006). Interestingly, the existing research documents that centralization in performance evaluation reduces the intensity of inter-jurisdictional interactions (Revelli, 2003; Revelli, 2006). On the contrary, our paper finds that the neighborhood effects increase along with centralization. We attribute this discrepancy to the distinct centralized control over personnel in China. The main channel of neighborhood effects in decentralized political systems is information spillover. In Besley and Case (1995), voters compare public services and taxes in different jurisdictions to help evaluation incumbents' performance. As a result, government officials take account of other jurisdictions' choices while making their own policies, hence resulting in spatial correlations. In Revelli (2006), the performance evaluation by the central government switches the focus of the local governments from horizontal interaction among local governments toward vertical reaction to the central government. While in China, the main channel of neighborhood effects is the RPE conducted by upper level governments. Emphasis on safety regulation in such a centralized state renders its greater salience in political competition, which leads to stronger neighborhood effects.

Finally, our paper is related to several papers on the regulation over workplace safety in China. Jia and Nie (2015) document a negative effect of decentralization on the coal mine safety due to the collusion between local governments and coal mining companies. Nie, Jiang, and Wang (2013) find that the provincial death rates in the coal mining industry were significantly lower as the "two sessions" were approaching. Fisman and Wang (2016) study the incentive distortions due to the implementation of "death ceilings", a threshold of deaths related to promotion and sanction. The mechanisms being investigated in these papers are consistent with the logic of neighborhood effects under RPE. These papers do not focus on neighborhood effects. The mechanisms they investigate are nevertheless relevant to explaining the performance correlation arising out of "contextual interactions" (Manski, 2000), i.e. the overall improvement in safety was driven by reactions to common policy shocks. In the empirical analysis we provide several tests to detect whether our estimates are driven by contextual rather than strategic interactions.

3 Analytical Framework

In this section we lay out a simple model to understand the neighborhood effects in coal mine disasters. The model consists of N agents, indexed as $i \in \{1, 2, ..., N\}$, and a principal, P. We can understand the agent as the head of a city government, and the principal as the upper level government[2]. Each agent chooses its own level

[2]In China the direct principal of cities is the provincial government. We focus on the interactions among city governments and hence abstract away the difference between the provincial and the central government.

of coal mine deaths (or equivalently, the safety level), y_i, while its payoff is jointly determined by the levels of coal mine deaths in own and other cities (neighbors)[3]. Each agent's payoff consists of economic gains derived from its coal mining industry and political rewards yielded by keeping satisfactory safety level. Neighborhood effects in coal mine disasters arise out of market interactions, which determine the agent's economic gain, and the RPE, which affect the agent's political rewards. Formally, city i's total economic gain from the coal mining industry is a function of deaths in i and its neighbors:

$$R_i = f(y_i, s\overline{y}_{-i}; \eta_i), \tag{1}$$

where y_i is the level of coal mine deaths in city i. $\overline{y}_{-i} \equiv \sum_{j \neq i} y_j$ 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 the economic gains: larger s means more integrated markets or stronger spillovers. η_i is a vector of i's fixed characteristics, such as the quality of coals, mining productivity, and market power of coal mining firms in i. The reduction of coal mine deaths (or the improvement of coal mine safety, smaller y_i) is costly as it requires cut-downs in production capacity and switching to safer and more expensive technologies, both of which raise the production costs and reduce the profitabilities of the coal mining firms. Since these firms contribute to the local government's revenue, R_i decreases. We assume that $\frac{\partial f}{\partial y_i} \equiv f_1 > 0$, and $\frac{\partial^2 f}{\partial y_i^2} \equiv f_{11} < 0$.

The safety in neighbors may affect city i's economic gains via either competition among mining companies in different cities, or technology or information spillovers. Neighbors' impact through market interactions is captured by $\frac{\partial f}{\partial (s\overline{y}_{-i})}$. A priori we do not commit ourselves to specific assumptions about the sign of market interactions. If competition dominates, i.e. an increase of neighbors' disasters is accompanied by their supply expansions and/or price reductions, i's (marginal) economic gains

[3]For analytical tractability, we assume that there is no uncertainty and that city governments can directly choose the level of coal mine disasters. This is in concord with existing literature claiming that local governments play a key role in determining the coal mine safety in their jurisdictions, although they do not directly own many of the coal mining firms (Wright, 2004; Wang, 2006; Jia and Nie, 2015).

should be negatively correlated with $\overline{y}_{-i}$: $\frac{\partial f}{\partial(s\overline{y}_{-i})} \equiv f_2 < 0$, and $\frac{\partial^2 f}{\partial y_i \partial(s\overline{y}_{-i})} \equiv f_{12} < 0$. On the contrary, if there is positive information spillovers in the market, coal mining companies can learn from neighbors how to acquire technologies that are both safe and profitable. i's (marginal) economic gain then is positively correlated with $\overline{y}_{-i}$: $f_2 > 0$ and $f_{12} > 0$.

Political competition among agents is implicitly modeled. Specifically, agent i's political gains (or cost) depends on deaths in its own and its neighbors. The political gain is in the following form:

$$G_i = g(y_i, \beta_P \overline{y}_{-i}; \eta_i, \psi_P), \tag{2}$$

We assume that the principal uses the RPE as a base to determine political rewards and costs. The use of the average level of neighbors' deaths, $\overline{y}_{-i}$, naturally follows from Theorem 8 in Holmstrom (1982). 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, this assumption can be understood as agents having stronger incentives to keep up with their neighbors when falling behind. The intensity of the RPE is captured by $\beta_P \geq 0$, which is the main choice variable set by the principal. Larger β_P suggests that each agent receive more severe punishment when their performances are relatively worse than their neighbors. η_i is a vector of cities' political characteristics, and ψ_P is a vector of the principal's characteristics.

The utility function of city government i, u_i, is a weighted average between economic and political gains:

$$u_i = \alpha_i R_i + (1 - \alpha_i) G_i = \alpha_i f(y_i, s\overline{y}_{-i}; \eta_i) + (1 - \alpha_i) g(y_i, \beta_P \overline{y}_{-i}; \eta_i, \psi_P), \tag{3}$$

where α_i is the weight agent i assigns to economic gains, and $1 - \alpha_i$ is the weight assigned to the political gains. α_i depends on city specific characteristics. A city already ranking high in terms of GDP growth (and thus rich in rents available for local officials) has less incentive to sacrifice workplace safety for economic gains, hence α_i is smaller. By contrast, cities with few coal mine deaths derives less marginal utility from political reward and is less incentivized to promote safety. Thus this accommodates a larger α_i.

Each agent $i \in \{1, 2, ..., N\}$ chooses a certain level of disaster, y_i, to maximize u_i, taking into consideration the tradeoff between the economic gains and the political costs associated with y_i. The principal's problem is to choose β_P, the intensity of RPE, to align the cities' incentive with hers so as to maximize her utility. Moreover, the principal faces a similar economy-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. A too large or too little $\bar{y}$ is unfavorable as it fails to balance the competing goals of economic growth and workplace safety. Formally, the principal's utility can be represented by the following quadratic loss function:

$$u_P = -(\overline{y} - \hat{y})^2. \tag{4}$$

We first analyze the Nash equilibrium of the subgame in which all agents simultaneously decide their y_i, taking the principal's incentive scheme as given. Agent i's best-reply is implicitly determined by the first order condition for maximizing u_i:

$$y_i^* = h(\overline{y}_{-i}; s, \alpha_i, \beta_P, \eta_i, \psi_P)^4. \tag{5}$$

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

$$\frac{\mathrm{d}y_i^*}{\mathrm{d}\overline{y}_{-i}} = \frac{-\alpha_i f_{12} s - (1-\alpha_i) g_{12} \beta_P}{\alpha_i f_{11} + (1-\alpha_i) g_{11}} \equiv \beta. \tag{6}$$

The neighborhood effect, defined as i's response to the performance of its neighbors, 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 $g_{11} = 0^5$. The

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

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

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 $\frac{\partial\beta}{\partial\alpha_i} = \frac{g_{12}\beta_P}{\alpha_i^2 f_{11}} < 0$. These 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 interaction among agents due to the RPE is positive and it is stronger when the RPE is more intensively used. These two claims provide a justification for our empirical analyses: we first estimate the slope of the best-reply function, β, and we then check whether the estimates vary with proxies for β_P and α_i.

Now turn to the problem of the principal. We are interested in showing how the principal's objective on coal mine safety affects the intensity of the RPE. To keep the intuition simple, we assume away agent heterogeneity by requiring that $\alpha_i = \overline{\alpha}$, $\eta_i = \overline{\eta}$. Thus in the (symmetric) equilibrium the level of disaster 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:

$$\frac{\partial \beta_P^*}{\partial \hat{y}} = -\frac{\hat{y} g_{12}(1-\overline{\alpha})}{\overline{\alpha}(f_{11}+sf_{12})+(1-\overline{\alpha})\beta_P^* g_{12}} \tag{7}$$

Equation (7) requires more scrutiny. It is obvious that 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 $sf_{12} > -f_{11}+\beta_P g_{12} > 0$, the denominator is positive and hence the overall sign of $\frac{\partial \beta_P^*}{\partial \hat{y}}$ is negative. When $sf_{12} < -f_{11}+\beta_P g_{12}$, the denominator is positive as $\overline{\alpha}$ is relatively small: $\overline{\alpha} < \frac{\beta_P^* g_{12}}{-f_{11}-sf_{12}+\beta_P^* g_{12}} \in (0,1)$, 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. This analysis yields the following result.

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: $sf_{12} > -f_{11}+\beta_P g_{12}$, or when agents attach enough importance over the coal mine disaster: $\overline{\alpha} < \frac{\beta_P^* g_{12}}{-f_{11}-sf_{12}+\beta_P^* g_{12}}$. Together with Claim 2 we have $\frac{\partial \beta}{\partial \hat{y}} < 0$.*

Claim 3 establishes a theoretical link between the magnitude of neighborhood effects and the principal's ideal target 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). Claim 3 also requires that $g_{12} > 0$, i.e., it become more difficult for agents to win political reward or to avoid penalties when neighbors' performance improve.

4 Institutional Background

The model suggests that (1) There are positive interactions with regard to coal mine safety resulted from the RPE; (2) Prioritizing coal mine safety in the RPE leads to stronger neighborhood effects: $\frac{\partial \beta}{\partial \beta_P} > 0$ and $\frac{\partial \beta}{\partial \alpha_i} < 0$; And (3) the overall safety performance tends to be an increasing function of the intensity of the RPE: $\frac{\partial \overline{y}^*}{\partial \beta_P} < 0$. This section provides an overview for the institutional background in support of these points.

The regulation over coal mine safety was comparatively decentralized before the 2000s. City and county governments are responsible for monitoring mining operations, assessing disaster risks, sanctioning violations against regulation, and shutting down disqualified mines. Local regulatory agencies over workplace safety are supervised by local governments instead of by the State Administration of Workplace Safety (SAWS). Moreover, local governments control small and medium sized coal mines[6], which consist of a sizable share of local revenues.

Regulation over coal mines is of exceptional stake for city governments. The fatality rate in the early 2000s[7] amounts to 11 times of that of Russia, 15 times of India, and 140 times of the United States (Wright, 2004). In terms of economic importance, coal supplies nearly 70 percent of domestic energy needs. Coal mines are economically important for local governments as they create jobs, fiscal revenues, and rents for officials. Enforcing stringent safety regulation significantly reduces these benefits. Thus, local governments face a dilemma when enforcing regulations, as equation (3) in the model illustrates. For city governments economically depending on coal production for revenues, the weight being assigned to economic gains (α_i) can be prohibitively high. Hence, they tend to be less responsive to the safety performance in the neighbors under the condition $\frac{\partial \beta}{\partial \alpha_i} < 0$ established by Claim 2.

The incentives of local governments, however, are ultimately structured by their principals. Xu (2011) characterizes the organization of the Chinese government as a "regionally decentralized authoritarian" system. Delegation and regional compe-

[6] The majority of these coal mines are managed by township and village owned enterprises, and they contribute to a large share of the total coal production.

[7] The rate is measured by the number of miners being killed for every million tons of coal produced.

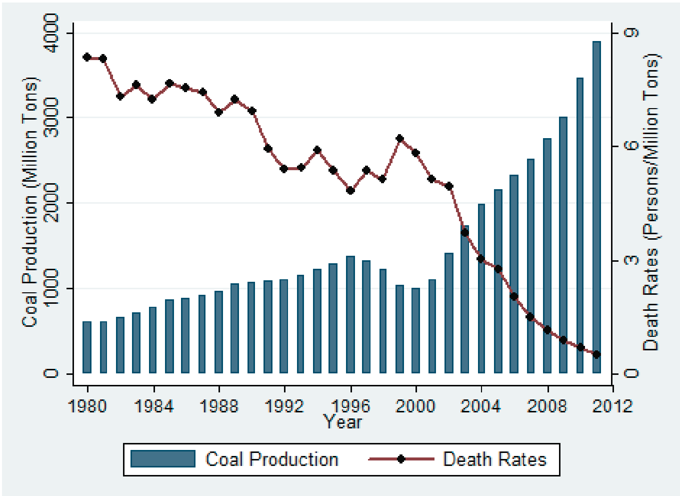
tition encourage subnational governments to initiate experimentations at the local level. In the meantime upper level governments retain the power to appoint, promote, and sanction local officials. Through this chain of control, the central government is able to fine tune the incentives of the local governments. To put in the theoretical framework, the principal chooses β_P to drive $\overline{y}$ to its ideal level $\hat{y}$.

In addition to the personnel control, the central government is able to exert direct influences by imposing sanctions. *The Workplace Safety Law* passed in 2002 specifies legal liabilities of local regulatory agencies and government officials for negligence in workplace disasters. In the August of 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. In turn, the "fatality indicators" become a primary base for the evaluation of local officials (Chan and Gao, 2012). 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. These reforms had transformed coal mine safety into a focal point. These reforms feature an increase of β_P in the RPE and hence stronger interactions.

The regulatory overhauls in the 2000s contrasts the practice in the 1980s and 1990s, when the state encouraged private investments and revenue creation by "wherever possible and by whatever means" (Wang, 2006). While the relative performance evaluation over quarterly deaths has been conducted in the 1990s, it did not have real impacts on promotions. Safety tends to be salient for local governments only when it is related to their careers. Regions with rampant deaths would then have strong incentives to curb disasters by "wherever possible and by whatever means". For example, it is reported that Si'chuan province was under particular pressure when it ranked "the first" in terms of the number of small mines after the closure of small mines (which are particularly unsafe) in Shan'xi province. The provincial minister of workplace safety in Si'chuan alluded to the campaign of reducing 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[8].

As Figure 1 shows, the first decade after the 2000s witnessed a sharp decline in coal mine deaths. The improvement on coal mine safety was not caused by cutdowns in production capacity, since the total output indeed expanded. We attribute the substantial decline in deathrates to regulations by local governments. In view of the model, this is induced by an increase in the intensity the RPE: a larger β_P. In turn, we should expect deaths to decrease, and interactions to become stronger, in the 2000s.

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



Notes: The data source is Chinese Coal Industry Yearbooks. The death rates are measured by the number of coal mine deaths per million tons of coal production.

5 Data

5.1 Coal Mine Deaths

We obtain the information about coal mine deaths from an online database of workplace disasters that is publicly available on the website of the State Administration of Workplace Safety (SAWS)[9]. The regulatory bureaus at each administrative level are responsible for reporting information about every disaster, including the

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

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

date, location, technical causes, and the number of deaths, to upper levels regulators. At least on paper, the process of reporting is regulated by rigid rules. In 1995, the Ministry of Coal Industry, the highest regulatory bureau overseeing coal mine safety at that time, required that the information of each disaster with any deaths be filed in 24 hours[10]. The *Workplace Safety Law* passed by the People's Congress in 2002 makes it a strict legal duty for regulators to investigate disasters and submit information to their superior counterparts. Moreover, regulators above county levels are required to publicize statistics on fatal disasters on a quarterly basis [11]. Bureaucrats and the business sector are subject to administrative sanctions and prosecutions when failing to comply with the law. Two regulatory statutes, respectively passed by the State Council in 2007 and by the SAWS in 2008[12], went further to require that local regulators workplace report disasters within two hours right afterwards.

We use the information on geographic locations and the dates of disasters provided from the online database, and aggregate the number of deaths to the quarter-city level. For our purpose, we restrict our sample to 151 major coal producing cities in 17 provinces in which coal stands as a non-trivial part of local economy. The coals produced by the cities in our sample account for 96.3 percent of the total production in 2010. The information provided by the SAWS dates back to the June of 2000 for some cities. It is not systemically documented, however, until 2001. For this reason we cover the period between 2001 and 2011.

The main variable of interest is the number of coal mine deaths in city i and quarter t. We take the logarithm of the deaths, $log(1+\#\ deaths_{i,t})$, as the dependent variable to account for the discrete distribution in the number of deaths. The main independent variable is the average of (log) deaths for all coal producing cities that

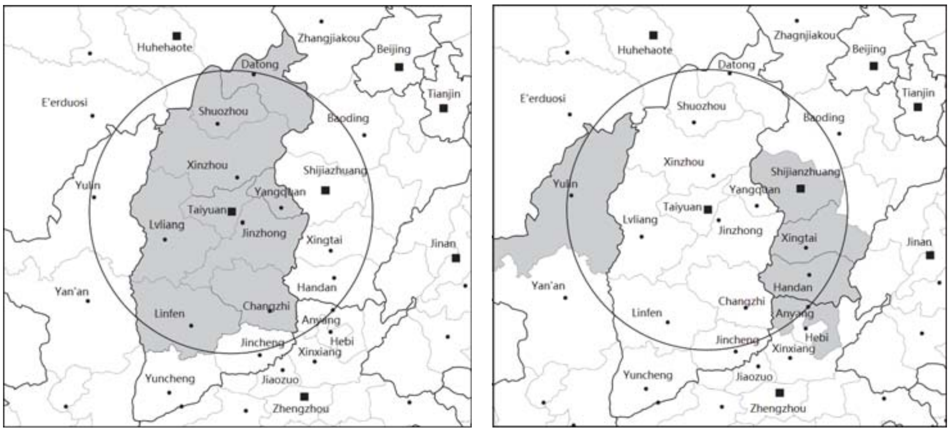
[10] *The Note on the Reports and Statistics of Coal Mine Disasters and Deaths* (*Meitan Gongye Qiye Zhigong Shangwang Shigu Baogao he Tongji Guiding*), implemented by the Ministry of Coal Industry on February 14, 1995. Retrieved at `http://www.chinasafety.gov.cn/file/fgmt/aqfg10.htm`

[11] *Workplace Safety Law of the People's Republic of China* (Zhonghua Renmin Gongheguo Anquan Shengchan Fa), promulgated by the People's Congress, June 29, 2002. Retrieved at `http://www.gov.cn/banshi/2005-08/05/content_20700.htm`

[12] *The Note on the Report and Investigation on Production Workplace Accidents* (the State Council, 2007) and *The Note on the Report and Investigation on Coal Mine Workplace Accidents* (the SAWS, 2008).

are characterized as city i's "neighbors" throughout quarter t. We define a city j as i's *political neighbor* if (1) the distance between the two cities' administrative centers is no larger than 250 kilometers[13]; and (2) j and i are located within the same province. The set for geographical (but not political) neighbors are coal producing cities located within 250 kilometers' radius and are from other provinces. In Section 7.2, we compare the baseline results using the performance of political neighbors to those using the performance of geographical, but not political, neighbors. The definition of these two types of neighbors is illustrated by Figure 2. The distinction between the two types of neighbors makes it possible to disentangle the neighborhood effects due to the RPE from those due to the market interaction, since the RPE operates only within a province, and the market interaction effect exists regardless of political jurisdiction.

Figure 2: Political and Geographical Neighbors: An Illustration



(a) Political Neighbors of Taiyuan

(b) Geographical (but not Political) Neighbors of Taiyuan

Notes: These two figures illustrate the political neighbors and geographical (but not political) neighbors of Taiyuan City, which is 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. Figure (a) illustrate the political neighbors of Taiyuan, cities whose centers are within the circle and the province. Figure (b) shows the geographical but not political neighbors of Taiyuan, cities whose centers are within the circle but beyond the provincial border.

Two kinds of measurement errors pose a threat to correctly identifying the neighborhood effects. First, the bureaucratic system may not be competent enough

[13]The calculation of geographic distance between cities uses the National-Standard longitude and latitude dataset (GB 2206-2) as a reference for cities' locations.

to timely process all disasters. The reporting rate may be lower in regions featured with lower bureaucratic capacity. This type of measurement error needs not bias the estimates for neighborhood effects as long as the bureaucratic capacity is not correlated with incentives. To the extent that the bureaucratic capacity is correlated with incentives, the estimates may be biased upward, when more motivated officials have higher competence and report disasters more accurately; Or, the estimates may be biased downward, when more competent officials are less motivated. To deal with this problem, we control for city fixed effects that capture time-invariant differences in the bureaucratic capacities. We also control for year-quarter fixed effects and provincial time trends to deal with time-variant effects that simultaneously drive safety performance in all cities within each province. We additionally control for (1) provincial specific effects for the Provincial Congress of the Communist Party, which is a dummy equal to 1 in the quarter of the Congress, as well as (2) the fixed effects of provincial party secretaries. The inclusion of dummies for political cycles and provincial party secretaries help alleviate the biases due to unobservables, such as the political connections of city officials.

The second kind of measurement error exists when regulatory agencies strategically under-report disasters to keep city officials in a good shape in political competition, as documented by Fisman and Wang (2016). This is likely a scenario when regulators collude with city governments, mayors and party secretaries in particular. However, note that the possibility of report manipulation may not necessarily undermine the identification of the neighborhood effects. City officials with strong incentives to improve safety indicators may simultaneously manipulate death reports. In this case, manipulation and real efforts push the neighborhood effects to the same direction. Thus, it is difficult to clearly disentangle the two, as Fisman and Wang (2016) admit. In Section 7.4 we provide several tests whether the neighborhood effects are inflated by manipulation, considering possible channels implied by Fisman and Wang (2016).

5.2 Control Variables

Coal Productions and Other Coal-related Variables We obtain the yearly data of coal productions at the city level from Statistics Yearbooks of provinces and cities. In addition, we control for the share of coal production from the state sector at the provincial level, using the information from the *Chinese Coal Industry Yearbooks* (CCIY). The prominence of non-state sector in the coal industry may imply a high amount of rents at the discretion of local governments, and thus, worse safety performance.

Road Traffic Accidents In Section 7.4 we test for the possibility that neighborhood effects are merely caused by correlated underreporting of coal mine casualties. The test involves using the average of (log) road accidents in the "neighborhood", which is calculated similarly as those of coal mine deaths, as an explanatory variable for city's own deaths. The information about road traffic accidents is obtained from the same online database provided by the SAWS.

Characteristics of Provincial and City Leaders In Section 7.6 we examine how the neighborhood effects are shaped by their principals, the provincial leaders. We construct a dummy variable indicating whether a provincial party secretary is aged between 59 and 63. This age range is the last time window for provincial party secretaries to be eligible for promotion, due to the limit of retirement ages in the cadre system. The information of provincial leaders are obtained from provincial yearbooks. We combine them with Internet sources such as *China Vitae*[14].

Socio-economic Characteristics We also explore whether the magnitudes of neighborhood effects vary with socioeconomic conditions at the city level. Specifically, we consider cities' relative rankings of per capita GDP growth and coal mine safety in the preceding year. A city which ranks higher in terms of the growth tends to have larger political returns over the improvement on safety. Likewise, the RPE with regard to safety may have higher stake when a city lags behind on safety. Finally, we include real GDP per capita, the share of value added from the secondary industries, the quantity of freight transports, and the population density at the city level to further control for variables confounding the estimation of neighborhood

[14] `http://chinavitae.com/`

effects. The data for socioeconomic characteristics were collected from *China City Statistics Yearbooks*. The summary statistics of main variables are provided by Table 1.

6 Empirical Strategy

The theoretically-derived result in (5) is approximated by the following linear equation:

$$y_{i,t} = \beta \sum_{j \in N(i)} \omega_{ij} y_{j,t} + X_{i,t}\theta + \lambda_i + \eta_t + t \times d_p + \kappa_c \times d_p + \mu_l + \epsilon_{it}. \tag{8}$$

$y_{i,t}$ is the number of coal mine deaths that occurred in city i (of province p) during year-quarter t. We specify that $y_{i,t}$ be $\log(1 + \#\ deaths_{i,t})$ so as to avoid the problem of discrete dependent variables.[15] It corresponds to y_i^*, the safety performance of i in equation (5). $j \in N(i)$ denotes cities located in i's neighborhood, and in the baseline it is defined as all cities (1) that are from the same province p; and (2) that are located within the 250 kilometers radius of the administrative center of city i. We assume that all neighbors have equal impacts on the incentive of i, thus $\omega_{ij} = \frac{1}{||N(i)||}$, where $||N(i)||$ is the number of cities in i's neighborhood. So $\sum_{j \in N(i)} \omega_{ij} y_{j,t-1}$ is the arithmetic average of all $y_{j,t}$'s in the neighborhood $N(i)$ in quarter t. It is an analogue of $\overline{y}_{-i}$ in the model.

$\mathbf{X_{it}}$ is a vector of control variables, which contains city-year level variables including the logarithm of real GDP per capita, the logarithm of coal production, the percentage share of secondary industries, and the logarithm of population density. In addition, $\mathbf{X_{it}}$ contains the arithmetic average of all these variables of neighbors to account for confounding contextual factors. ϵ_{it} is the term for random disturbance. For all estimations we cluster standard errors at the city level. We also report spatial standard errors proposed by Conley (1999)[16].

[15] Specifying y_{it} as the number of deaths in coal mine disasters requires the using of count data models, such as Poisson or negative binomial models for estimation. The results are qualitatively identical to those using the logarithms of deaths.

[16] The Stata code is provided by Hsiang (2010).

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Data Source
	City-Quarter Number of Coal Mine Deaths					
log(1+Deaths)	6644	0.510	0.913	0	5.214	1
	# of Cities in Neighborhoods					
Same Province	6644	9.444	2.664	4	15	2
Same Province, 200 km	6644	4.974	2.762	1	11	2
Same Province, 250 km	6644	6.265	3.122	1	13	2
Same Province, 300 km	6644	7.152	3.257	1	14	2
Other Provinces, 200 km	6644	3.325	2.355	1	12	2
Other Provinces, 250 km	6644	5.629	3.709	1	17	2
Other Provinces, 300 km	6644	8.907	5.320	1	23	2
	City-Year Data					
log(Real GDP Per Capita) (RMB)	6644	9.309	0.704	4.357	11.835	3
GDP Share of Secondary Industry (Percentage Points)	6644	47.513	11.977	0.000	85.640	3
log(Freight Transport) (Ten Thousand Tons)	6644	8.464	0.859	4.663	11.055	3
log(Population Density)(Persons/Sq.km)	6644	5.446	0.961	1.548	7.213	3
log(Coal Production) (Ten Thousand Tons)	6644	5.811	1.948	-0.329	10.982	4
Ranking of Per Capita GDP Growth Rate	6644	0	0.974	-4.014	4.644	3
Ranking of Coal Mine Safety Conditions	6644	0	0.975	-1.440	5.295	5
	Province-Year Level Data					
NSOE Share of Coal Production (Percentage Points)	6644	37.303	26.378	0	91.192	5
1(Provincial Party Secretary's Age is Between 59 and 63)	6644	0.513	0.500	0	1	6

Notes: Our sample only covers 151 coal producing cities in 44 quarters from 2001 to 2011. Neighborhoods also contain coal producing cities only. For all year-level variables, their values are the same in four quarters within a year, and we have 6644 observations (151 cities and 44 quarters) for these variables. The ranking of a province (city) i's per capita GDP growth rate in year t is defined as $rank_{g,i,t} \equiv \frac{g_{i,t}-m(g)_t}{sd(g)_t}$, where $g_{i,t}$ is i's growth rate in year t, $m(g)_t$ is the mean of all provinces (city) i's growth rates in the country (province), and $sd(g)_t$ is the standard deviation. Similarly, the ranking of a province (city) i's safety in year t is defined as $rank_{d,i,t} \equiv \frac{d_{i,t}-m(d)_t}{sd(d)_t}$, where $d_{i,t}$ is i's deathrate in year t, $m(d)_t$ is the mean of all provinces' (cities') deathrates in the country (province), and $sd(d)_t$ is the standard deviation.

Data sources:
1. State Administration of Work Safety websites
2. National-Standard city coordinate dataset (GB 2206-2)
3. China City Statistics Yearbook
4. Statistics yearbooks of each city and province
5. China Coal Industry Yearbook
6. Internet Sources (such as China Vitae, Baidu, and Wikipedia)

We include a set of fixed effects and temporal trends to deal with potential biases due to unobservables. For all estimations, we control for the city and year-quarter fixed effects, along with provincial time trends and political cycles. This helps disentangle contextual factors that commonly drive the reactions of the cities. City fixed effects, λ_i, address the possibility that there is time-invariant discrepancies across cities in terms of the bureaucratic capacity to improve safety. The year-quarter fixed effects, η_t, control for the impacts of temporal shocks, including the central government's policies, that may have induced simultaneous response from all cities.

In addition to city and time fixed effects, we include several provincial time variables to account for contextual interactions. One possibility is that over time cities in different provinces improve performance indicators at different rates. To account for this, we include $t \times d_p$, a vector of provincial time trends. City governments' responses for safety regulations are also related to political turnovers. We control for $\kappa_c \times d_p$, the provincial specific effects for the Provincial Party Congress, as well as μ_l, a vector of fixed effects for provincial party secretaries. Because city officials are supervised by provincial governments, and political connections may affect regulation and safety (Jia, 2012; Fisman and Wang, 2015), the including $\kappa_c \times d_p$ and μ_l also helps alleviate the bias due to political connections.

The main parameter of interest is β, the coefficient on $\sum_{j \in N(i)} \omega_{ij} y_{j,t}$. Performing OLS estimation for specification (8) requires that the average term for neighbors' deaths ($\sum_{j \in N(i)} \omega_{ij} y_{j,t}$) be uncorrelated with ϵ_{it}. This assumption is obviously violated since in equation (8) $y_{i,t}$ and all $y_{j,t}$ ($j \in N(i)$) are simultaneously determined. Thus, β, the term representing strategic interactions in the best response equation (5), is not correctly estimated by equation (8). We adopt two approaches to deal with this reflection problem. First, 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 related to $y_{j,t}$ but not directly correlated with ϵ_{it}. Also, this specification implies a dynamic data generating process for $y_{i,t}$, and hence we also include its own one-period lag, $y_{i,t-1}$, in the RHS of the specification. Formally, we extend the baseline specification

(8) to the following dynamic model:

$$y_{i,t} = \alpha y_{i,t-1} + \beta \sum_{j \in N(i)} w_{ij} y_{j,t-1} + X_{i,t}\theta + \lambda_i + \eta_t + t \times d_p + \kappa_c \times d_p + \mu_l + \epsilon_{it}. \quad (9)$$

Secondly, we adopt Lee and Yu (2010)'s approach to estimate equation (8) using the quasi-maximum likelihood estimation (QMLE). QMLE provides a consistent estimator that takes into account the potential endogeneity issues due to the spatial interdependence in the data (which is equivalent to a Spatial Autoregressive (SAR) model), and the incidental parameter problems raised by incorporating fixed effects. It involves data transformation in the first step which eliminates both individual and time fixed effects, and then the maximization of the likelihood function conditional on the transformed data. Thus, different from traditional approaches of maximum likelihood estimation, it yields consistent estimates with properly centered distributions.

7 Results

7.1 Baseline Results

Table 2 presents the baseline results about cities' responses to the safety performance in their political neighbors whose administrative centers are located within the 250 kilometers radius. Column 1 through 3 report the estimates based on the specification (9), which uses the one-period lag of neighbors' average and controls for the lagged dependent variable, $y_{i,t-1}$. The results from column 4 through 6 are obtained by estimating the spatial autoregressive model using the QMLE. The estimations adopt contemporaneous terms of neighbors' deaths and do not include the lagged dependent variables. The coefficients on neighbors' performance capture strategic interactions among city governments with regard to coal mine deaths. Note that the sign of strategic interactions is determined by not only political incentives under the RPE, but also market interactions, as Claim 1 suggests. In principle, the coefficient for the neighborhood effects can be negative when market interaction effects are negative. Hence, a positive and robust estimate for β is suggestive of the significance of political competition.

Column 1 through 6 report positive and statistically significant coefficients on neighbors' safety performance. The results are robust to the inclusion of provincial time trends, provincial specific dummies for the national political cycles, and the dummies to capture the influences of provincial party secretaries. Using clustered standard errors and spatial standard errors yield similar results.

The coefficients based on the contemporaneous terms are about twice as large as those based on the lagged terms. This difference suggests that the impacts of past performance on the current performance declines over time, presumably because the performance evaluation is conducted on a quarterly base. Hence, the incentives of local governments stems from instantaneous competition with their neighbors, and not so much from past information. Interestingly, as column 1 to 3 illustrates, the lagged performance of political neighbors has a larger impact on a city's performance than its own past performance. We attribute this to the importance of the RPE in shaping the incentives of city officials.

7.2 Political Versus Geographic Neighbors

The baseline results establish that strategic interactions lead to positive neighborhood effects among cities, however they do not separate political incentives under the RPE and the market interactions. To assess the possibility that coal mine deaths may actually be affected through the market interactions, we estimate the baseline models using alternative definitions for political and geographical neighbors. Markets in geographically closer cities are more integrated and hence firms wherein have stronger interactions. Thus, if neighborhood effects are mainly driven by the market interaction as opposed to by political competition, the influence of neighbors should be diluted when farther-away cities are included. Meanwhile, the magnitude of neighborhood effects should not be sensitive to geographic distances if the interactions are mainly driven by political competition.

As Table 3 demonstrates, the coefficients for neighborhood effects do not decrease as more distant cities are included int the neighborhood within the same

Table 2: Neighborhood Effects: Baseline Results

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: log(1+ # of Coal Mine Deaths)					
	OLS	OLS	OLS	QMLE	QMLE	QMLE
log(1+ # lag Coal Mine Deaths)	0.092***	0.0947***	0.0584***			
	(0.0193)	(0.0191)	(0.0191)			
Avg. log(1+ # lag Coal Mine Deaths), Same Province 250km	0.129***	0.134***	0.099***			
	(0.0330)	(0.0327)	(0.0330)			
Avg. log(1+ # Coal Mine Deaths), Same Province 250km				0.265***	0.270***	0.220***
				(0.0421)	(0.0409)	(0.0397)
Spatial Standard Error (200km)	[0.026]***	[0.026]***	[0.026]***			
Spatial Standard Error (250km)	[0.026]***	[0.027]***	[0.027]***			
Spatial Standard Error (250km)	[0.027]***	[0.027]***	[0.027]***			
Control Variables	Y	Y	Y	Y	Y	Y
Provincial Time Trend	Y	Y	Y	Y	Y	Y
Provincial Political Cycle	N	Y	Y	N	Y	Y
City FE	Y	Y	Y	Y	Y	Y
Year-Quarter FE	Y	Y	Y	Y	Y	Y
Provincial Party Secretary FE	N	N	Y	N	N	Y
Observations	6,493	6,493	6,493	6,644	6,644	6,644
R-squared	0.235	0.241	0.250	0.254	0.268	0.295
Number of Cities	151	151	151	151	151	151

Notes: The sample covers 151 coal producing cities and 44 quarters from 2001 to 2011. Controls include own's and neighbors' average of log real GDP per capita, percentage share of secondary industry, log population density, log freight transport, log coal production, and provincial percentage share of non-state coal production. Standard errors reported in parentheses are clustered at the city level. Standard errors reported in brackets are spatial standard errors (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table 3: Political Neighbors Versus Geographical Neighbors

	Panel A: OLS Estimation						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent Variable: log(1+ # of Coal Mine Deaths)						
log(1+ # lag Coal Mine Deaths)	0.0959***	0.0947***	0.0925***	0.0921***	0.0959***	0.0943***	0.0936***
	(0.0190)	(0.0191)	(0.0192)	(0.0191)	(0.0196)	(0.0196)	(0.0196)
	Cities in the Same Province				Cities in Other Provinces		
Avg. log(1+lag # Coal Mine Deaths)	200 km	250 km	300 km	All	200 km	250 km	300 km
	0.107***	0.134***	0.156***	0.164***	0.0160	-0.0222	-0.0589
	(0.0314)	(0.0327)	(0.0294)	(0.0406)	(0.0258)	(0.0271)	(0.0321)
Spatial Standard Error (200km)	[0.025]***	[0.026]***	[0.029]***	[0.029]***	[0.026]	[0.021]	[0.025]
Spatial Standard Error (250km)	[0.026]***	[0.027]***	[0.029]***	[0.029]***	[0.026]	[0.022]	[0.026]
Spatial Standard Error (300km)	[0.026]***	[0.027]***	[0.030]***	[0.029]***	[0.026]	[0.022]	[0.026]
Observations	6493	6,493	6493	6493	6493	6493	6493
R-squared	0.240	0.241	0.241	0.241	0.241	0.238	0.238
Number of Cities	151	151	151	151	151	151	151

	Panel B: Quasi-ML Estimation						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent Variable: log(1+ # of Coal Mine Deaths)						
	Cities in the Same Province				Cities in Other Provinces		
Avg. log(1+ # Coal Mine Deaths)	200 km	250 km	300 km	All	200 km	250 km	300 km
	0.220***	0.281***	0.288***	0.367***	-0.006	0.0149	0.0273
	(0.0423)	(0.0414)	(0.0265)	(0.0449)	(0.0353)	(0.035)	(0.0390)
Observations	6,644	6,644	6,644	6,644	6,644	6,644	6,644
R-squared	0.249	0.261	0.264	0.282	0.216	0.216	0.216
Number of Cities	151	151	151	151	151	151	151

Notes: The sample covers 151 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's and neighbors' average of log real GDP per capita, percentage share of secondary industry, log population density, log freight transport, log coal production, and provincial percentage share of non-state coal production. Standard errors reported in parentheses are clustered at the city level. Standard errors reported in brackets are spatial standard errors (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

province. The results are qualitatively similar when using linear regressions with lagged terms (Column 1 to 4 in the panel A) and when employing the QMLE with contemporaneous terms (Column 8 to 11 in the panel B).

When we move to the set of cities which are geographically close but supervised by other provincial governments, the estimates for neighborhood effects are utterly different, as Column 5 to 7 show. Nearby neighbors outside the province do not have any impacts on own deaths. Note that this discrepancy is not due to the lack of observations in the latter group. As a matter of fact, the numbers of cities falling into this category (geographically close but not in the same province) are about the same as those of the political neighbors, as Table 1 summarises. These findings suggest that market forces are unlikely to be a sole driver of the neighborhood effects. Provincial boundary is crucial in delineating neighborhood effects, because cities compete within the provincial boundary. This finding affirms that the inter-city interactions are more politically than economically driven.

7.3 Test for Contextual Interactions

Although we have used several sets of fixed effects to control for contextual effects, one can still argue that coal mine deaths in cities may be correlated with time-variant policies that simultaneously drive deaths across regions. To deal with this issue, we provide a falsification test for the possibility that the neighborhood effects we estimate in Table 2 are merely driven by policy shocks at the provincial level. We estimate the neighborhood effects in a similar fashion as in equation (8) but adopt higher-order time lags of the neighbors' deaths as the independent variable. The rationale is that regulatory overhauls should somewhat persist if they are to have any real impacts on safety. Because provincial governments are answerable to the central government, it does not make sense that deaths are cut down for only one period and relapse later. Thus, we should expect the higher-order lagged terms for neighbors' deaths to have similar significant effects on cities' own deaths.

Table 4 reports the estimates of the neighborhood effects using higher-order time lags. Contrary to what the proposed mechanism may predict, we do not find any significant effect once neighbors' performances are lagged no less than two quarters.

The lack of significance for neighbors' past performances reinforces the premise that the neighborhood effects are mainly fostered by the RPE conducted quarterly rather than by other contextual effects.

7.4 Are the Neighborhood Effects Driven by Misreporting?

Another possibility of context-driven neighborhood effects arises when reports about coal mine disasters are systematically suppressed in some regions for some periods. 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 performance set by provincial governments. This odd discontinuity suggests a possibility of report manipulation by local governments. Note that, however, the existence of manipulation does not necessarily invalidate the estimations for neighborhood effects in the context of coal mine deaths. Manipulation is likely to occur for the marginal cases around the "death ceilings". Yet the overall distribution of deaths is quite dispersed and in most cases far below the thresholds. Hence, our estimates for neighborhood effects can still be informative about city officials' real efforts on safety. The issue to be investigated, then, is whether manipulation biases the estimations for neighborhood effects.

In Table 5 we adopt several falsification tests to account for the influence due to manipulation. Fisman and Wang (2016) document that the discontinuity occurs at the province-year level but not for the cumulative deaths in the first three quarters of each year. This is interpreted as evidence of manipulation because local governments pay more attentions to safety near the end of the year, when annual evaluations are conducted. Following this logic, we exclude the fourth quarters and re-estimate the baseline model. We should expect no significant results if the previous estimations are merely driven by manipulation. The Panel A of Table 5 shows that neighborhood effects are robust in estimations based on the first three quarters.

In the second falsification test, we include an interaction term between city's distance to the provincial capital and the average of neighbors' deaths. When a city is located farther away from the administrative center, the supervision cost becomes higher and manipulation becomes more prevalent. We employ distance to

Table 4: Testing Contextual Effects: Higher Order Time Lags

	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths) OLS Estimation			
Avg. log(1+ # Coal Mine Deaths), Same Province 250km	0.134***			
	(0.0327)			
Avg. log(1+ lag 2 # Coal Mine Deaths), Same Province 250km		0.0123		
		(0.0267)		
Avg. log(1+ lag 3 # Coal Mine Deaths), Same Province 250km			0.0197	
			(0.0300)	
Avg. log(1+ lag 4 # Coal Mine Deaths), Same Province 250km				-0.0376
				(0.0304)
Spatial Standard Error (200km)	[0.026]***	[0.026]	[0.029]	[0.027]
Spatial Standard Error (250km)	[0.027]***	[0.026]	[0.030]	[0.028]
Spatial Standard Error (300km)	[0.027]***	[0.027]	[0.030]	[0.028]
Observations	6,493	6,342	6493	6493
R-squared	0.241	0.246	0.250	0.254
Number of Cities	151	151	151	151

Notes: The sample covers 151 coal producing cities and 44 quarters from 2001 to 2011. In all columns city and year-quarter fixed effects, provincial time trend, and provincial political cycles are included.Controls include own's and neighbors' average of log real GDP per capita, percentage share of secondary industry, log population density, log freight transport, log coal production, and provincial percentage share of non-state coal production. Standard errors reported in parentheses are clustered at the city level. Standard errors reported in brackets are spatial standard errors (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

Table 5: 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			
Avg. log(1+lag # Coal Mine Deaths)	200 km	250 km	300 km	All
	0.122**	0.151***	0.169***	0.169***
	(0.0355)	(0.0377)	(0.0384)	(0.0466)
Spatial Standard Error (200km)	[0.029]**	[0.031]***	[0.035]***	[0.042]***
Spatial Standard Error (250km)	[0.030]**	[0.031]***	[0.036]***	[0.043]***
Spatial Standard Error (300km)	[0.030]**	[0.031]***	[0.036]***	[0.043]***
Observations	4832	4832	4832	4832
R-squared	0.242	0.242	0.242	0.242
Number of Cities	151	151	151	151
	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			
Avg. log(1+Coal Mine Deaths)	200 km	250 km	300 km	All
	0.135*	0.136*	0.146*	0.145*
	(0.0732)	(0.0805)	(0.0860)	(0.0864)
Avg. log(1+Coal Mine Deaths)* log(1+Distance)	-0.00319	0.00226	0.00507	0.00822
	(0.0148)	(0.0160)	(0.0170)	(0.0179)
Observations	6,493	6,493	6,493	6,493
R-squared	0.250	0.250	0.251	0.251
Number of Cities	151	151	151	151
	Panel C: Placebo Tests Using Road Traffic Deaths			
	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths)			
	Cities in the Same Province			
Avg. log(1+ # Road Traffic Deaths)	200 km	250 km	300 km	All
	-0.00380	0.00922	0.0151	-0.00809
	(0.0139)	(0.0146)	(0.0148)	(0.0230)
Spatial Standard Error (200km)	[0.010]	[0.011]	[0.012]	[0.020]
Spatial Standard Error (250km)	[0.010]	[0.011]	[0.012]	[0.020]
Spatial Standard Error (300km)	[0.011]	[0.012]	[0.013]	[0.021]
Observations	6,644	6,644	6,644	6,644
R-squared	0.230	0.230	0.230	0.230
Number of Cities	151	151	151	151

Notes: The sample covers 151 coal producing cities and 44 quarters from 2001 to 2011. In all columns city and year-quarter fixed effects, provincial time trends, and provincial political cycles are included. Controls include own's and neighbors' average of log real GDP per capita, percentage share of secondary industry, log population density, log freight transport, log coal production, and provincial percentage share of non-state coal production. Standard errors reported in parentheses are clustered at the city level. Standard errors reported in brackets are spatial standard errors (Conley, 1999). * Significant at 10%, ** 5%, *** 1%.

the provincial capital as a proxy for the degree of manipulation. If estimations for neighborhood effects are driven by manipulation, cities more attempting to manipulate should appear to be more "responsive". The interaction term should then be positive. Contrary to this hypothesis, Panel B of Table 5 shows that the coefficients on interaction terms are insignificant and small. On top of that the average term for neighbors' performance remains significant at the 0.1 level and the magnitudes of coefficients are similar to those in the baselines.

Finally, we use road traffic accidental deaths of neighbors to conduct a placebo test. As Fisman and Wang (2016) and Jia and Nie (2015) show, the manipulation exists for various types of accidental deaths. Since manipulations stem from the promotion incentives of city officials, we expect that they are correlated on different accident categories. We can use neighbors' road traffic accidental deaths to determine whether manipulations drive neighborhood effects. For city governments, observing a high degree of declines (manipulations) in neighbors' road accidental deaths reinforces their incentives of manipulation. The results presented in the Panel C of Table 5 reject this hypothesis. Altogether, these tests suggest that the manipulation has not biased our estimates.

7.5 Impacts of Policy Changes at the National Level

We conduct a set of difference-in-difference estimations to determine whether neighborhood effects vary at the national, provincial, and city levels. We focus on two institutional variations at the national level: the empowerment of regulatory regime after 2005 and the timing of political cycle due to the National Party Congress. As Section 4 describes, the recent decade witnesses an expansion in the power of regulatory agencies, particularly after the upgrading of the SAWS in 2005. The implementation of administrative accountability system for local governments in 2005 features an increase in the safety target of the central government, i.e. smaller $\hat{y}$. As Claim 3 shows, under the RPE the positive neighborhood effects tend to be stronger when the principal aims higher on coal mine safety, provided that the market interactions do not produce a large negative impact on neighborhood effects. We add the interactions between the lagged term for neighbors' deaths and the dummy for the post-2005 years to the estimations of equation (8). As expected, the magnitudes of the neighborhood effects become significantly larger in the post-2005 years. The coefficients on neighbors' deaths remain significant, suggesting that the results are not solely driven by the reforms in the post-2005 years.

In the Panel B of Table 6, we control for the interaction term between neighbors' deaths and the time span to the next Convention of the National Party Congress (in quarters). The literature has documented policy fluctuations following political cycles in developing countries (Block, 2002; Shi and Svensson, 2006; Guo, 2009). In China the political cycles follow the Convention of the National Party Congress (CNPC), which takes place every five years. As promotion incentives get stronger toward the CNPC, we expect cities to be more focused on coal mine safety. Neighborhood effects should hence become stronger. Thus, the interaction term should be negative. The results presented in Column 1 through 4 of Panel B attest to this prediction. Again, for varying scopes of political neighbors, we find robust positive effects, which are significantly larger when the date is closer to the CNPC.

7.6 Provincial Leaders' Incentives

We also examine the heterogeneity in neighborhood effects at the provincial level. Claim 2 maintains that when the neighborhood effect is positive, it is stronger in provinces where the RPE is more intensely used (larger β_P). We use the age of provincial party secretary to test this hypotheses.

We construct an age dummy indicating strong promotion motives due to retirement age limit for provincial party secretaries. Provincial party secretaries are mandated to retire by 65, with exceptions being made only occasionally to allow them to serve a full term. For as early as two years before the retirement, the officials will be transferred to less powerful positions with the same administrative rank[17]. Thus, during the age range between 59 and 63 provincial party secretaries have strongest promotion motives, in that they have to grasp the last opportunity for promotion. Then, these officials would be more committed to the policy goal of

[17]The recent case in July 2016 is that the former party secretaries of Shan'xi, Jiangsu, and Jiangxi, whose ages were respectively 63, 65, and 63, were appointed as deputy chairs on sub-committees under the National People's Congress.

Table 6: Impacts of Policy Changes at the National Level

	Panel A: Regime Change in 2005			
	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths)			
	Cities in the Same Province			
	200 km	250 km	300 km	All
Avg. log(1+Coal Mine Deaths)	0.096**	0.076*	0.095**	0.0759
	(0.038)	(0.0425)	(0.0454)	(0.048)
Avg. log(1+Coal Mine Deaths)*1(After 2005)	0.0909**	0.111**	0.117**	0.174***
	(0.0422)	(0.0449)	(0.0505)	(0.0566)
Observations	6493	6493	6493	6493
R-squared	0.241	0.242	0.243	0.242
Number of Cities	151	151	151	151

	Panel B: Proximity of the National Party Congress			
	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths)			
	Cities in the Same Province			
	200 km	250 km	300 km	All
Avg. log(1+Coal Mine Deaths)	0.141***	0.166***	0.196***	0.204***
	(0.0363)	(0.0359)	(0.0377)	(0.0435)
Avg. log(1+Coal Mine Deaths)* # Quarters to the Next Party Congress	-0.166***	-0.162***	-0.201***	-0.191***
	(0.0512)	(0.0515)	(0.0522)	(0.0576)
Observations	6,493	6,493	6,493	6,493
R-squared	0.242	0.243	0.244	0.242
Number of Cities	151	151	151	151

Notes: The sample covers 151 coal producing cities and 44 quarters from 2001 to 2011. In all columns city and year-quarter fixed effects, provincial time trends, and provincial political cycles are included. Controls include own's and neighbors' average of log real GDP per capita, percentage share of secondary industry, log population density, log freight transport, log coal production, and provincial percentage share of non-state coal production. Standard errors reported in parentheses are clustered at the city level. * Significant at 10%, ** 5%, *** 1%.

the central government, which is stringent regulation over coal mine safety. According to Claim 2 and 3, the RPE over coal mine safety will be more intensively used (larger β_P) and the neighborhood effects are stronger (larger β).

The results from Column 1 to 4 show that neighborhood effects are indeed stronger when the provincial party secretaries are aged between 59 and 63, which is consistent with the above analysis. Also note that in all columns the estimates for neighbors' deaths per se are positive and significant. Furthermore, this result confirms the previous finding about democratically politicians that positive spatial interactions exist only for officials with reelection motives (Bordignon, Cerniglia, and Revelli, 2003).

7.7 City Heterogeneity

Finally, incentive schemes may be shaped by regions' previous relative performances with regard to economic growth and coal mine safety. Coal mine deaths damage the promotion prospect of officials. Thus, when a city enjoys a higher growth rate, the opportunity cost of sacrificing safety for growth is larger. On the other hand, when a city falls behind on safety, city officials are more likely to face various kinds of penalties ranging from losing promotion competition to being sanctioned. Hence, cities with worse performance should care more about political costs associated with coal mine deaths. We expect α_i to be smaller in these two cases.

In Table 8, the ranking of city i's GDP growth within the province in year t is computed as $rank_{g,i,t} \equiv \frac{g_{i,t}-m(g)_t}{sd(g)_t}$, where $g_{i,t}$ is the annual growth rate of GDP per capita, $m(g)_t$ is the mean of all cities' growths, and $sd(g)_t$ is the standard deviation of all cities' growths. By a similar token, the ranking of a city i's safety in year t is defined as $rank_{d,i,t} \equiv \frac{d_{i,t}-m(d)_t}{sd(d)_t}$, where $d_{i,t}$ is i's annual deathrate, $m(d)_t$ is the city average of deathrates, and $sd(d)_t$ is the standard deviation. We interact the rankings with neighbors' performance and estimate heterogeneous responses to neighbors' performance. Both rankings are lagged one year to avoid the endogeneity problem. The results in Table 8 show that neighborhood effects are stronger (1) when a city ranks higher on GDP growth in the province; and (2) when the city ranks lower on safety in the province. These findings are consistent with Claim 2 that city officials

Table 7: Provincial Party Secretaries' Age

	(1)	(2)	(3)	(4)
	Dependent Variable: log(1+ # of Coal Mine Deaths)			
	Cities in the Same Province			
Average log(1+lag # Coal Mine Deaths)	200 km	250 km	300 km	All
	0.0792**	0.102**	0.103**	0.0855*
	(0.0381)	(0.0409)	(0.0448)	(0.0515)
1(Provincial Secretary's Aged Between 59 and 63)	-0.0434	-0.0476	-0.0648**	-0.0864***
	(0.0274)	(0.0289)	(0.0301)	(0.0300)
Average log(1+lag # Coal Mine Deaths)*1(Provincial Secretary's Age is Between 59 and 63)	0.0646	0.0702*	0.106**	0.147***
	(0.0418)	(0.0431)	(0.0463)	(0.0486)
Observations	6,493	6,493	6,493	6,493
R-squared	0.240	0.240	0.240	0.240
Number of Cities	151	151	151	151

Notes: The sample covers 151 coal producing cities and 44 quarters from 2001 to 2011. In all columns city and year-quarter fixed effects, provincial time trends, and provincial political cycles are included. Controls include own's and neighbors' average of log real GDP per capita, percentage share of secondary industry, log population density, log freight transport, log coal production, and provincial percentage share of non-state coal production. Standard errors reported in parentheses are clustered at the city level. * Significant at 10%, ** 5%, *** 1%.

who value more the political rewards associated with coal mine safety (smaller α_i) respond more strongly to the neighbors' safety performances.

8 Conclusion

In this paper, we study neighborhood effects within a bureaucratic system when RPE is utilized as a mechanism for political selection. We empirically examine the coal mine safety in China as a case in point. The key finding is that the number of coal mine deaths of a city responds positively to those of their political neighbors within the same province, but not to those of their geographical neighbors outside the province. A set of city and time fixed effects together with falsification tests suggest that strategic competition among city officials is the main reason for the neighborhood effects. The increase in the intensity of strategic competition after 2005 is consistent with the overhauls of regulatory system of coal mine safety at the national level. Exploring provincial and city characteristics shows that the strength of these effects is positively associated with the principal's object of safety, and with agent's care about the political costs related to safety.

The mechanism of the RPE is crucial in driving the neighborhood effects in bureaucratic organizations. When local officials face the same evaluation criteria and compete for the same upper level positions, their performances are correlated. Moreover, the principals can use personnel control to drive policy outcomes toward their own targets. This explains why local governments shifted to devoting more efforts to issues traditionally conceived as "second-dimensional", such as the coal mine safety. The logic for the neighborhood effects under the RPE may also apply to a wide range of other policy issues, such as environmental regulation and law enforcement.

Table 8: Cities' Rankings on GDP Growth and Deaths

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent Variable: log(1+ # of Coal Mine Deaths)							
	Cities in the Same Province				Cities in the Same Province			
Average log(1 + # Coal Mine Deaths)	200 km	250 km	300 km	All	200 km	250 km	300 km	All
	0.102***	0.127***	0.145***	0.146***	0.144***	0.172***	0.196***	0.212***
	(0.0315)	(0.0340)	(0.0398)	(0.0465)	(0.0329)	(0.0342)	(0.0373)	(0.0419)
Lag Growth Ranking	-0.0354**	-0.0359**	-0.0361**	-0.0256*				
	(0.0138)	(0.0139)	(0.0146)	(0.0141)				
Lag Death Ranking					0.100***	0.0980***	0.0993***	0.100***
					(0.0162)	(0.0167)	(0.0171)	(0.0180)
Average log(1 + # Coal Mine Deaths)* Lag Growth Ranking	0.0632***	0.0608**	0.0593**	0.0385				
	(0.0229)	(0.0240)	(0.0241)	(0.0252)				
Average log(1 + # Coal Mine Deaths)* Lag Death Ranking					0.149***	0.157***	0.196***	0.174***
					(0.0258)	(0.0244)	(0.0225)	(0.0281)
Observations	6,493	6,493	6,493	6,493	6,323	6,323	6,323	6,323
R-squared	0.264	0.262	0.262	0.260	0.255	0.255	0.255	0.254
Number of Cities	151	151	151	151	151	151	151	151

Notes: The sample covers 151 coal producing cities and 44 quarters from 2001 to 2011. In all columns city and year-quarter fixed effects, provincial time trend, and provincial cycles are included. Controls include own's and neighbors' average of log real GDP per capita, percentage share of secondary industry, log population density, log freight transport, log coal production, and provincial percentage share of non-state coal production. * Significant at 10%, ** 5%, *** 1%.

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